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FRANK W. PATTERSON.

MAY, 1915 MEMOIR No. 6

CORNELL UNIVERSITY
AGRICULTURAL EXPERIMENT STATION
OF THE COLLEGE OF AGRICULTURE

FUSARIA OF POTATOES

BY C. D. SHERBAKOFF

FORMERLY OF THE DEPARTMENT OF PLANT PATHOLOGY, CORNELL UNIVERSITY
NOW ASSOCIATE PLANT PATHOLOGIST, AGRICULTURAL EXPERIMENT STATION, UNIVERSITY OF FLORIDA

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FUSARIA OF POTATOES

FUSARIA OF POTATOES[1]

C. D. Sherbakoff

INTRODUCTORY

The purpose of this work has been to lay down a basis for the study of the disease known as the fusarial wilt and dry rot of potatoes, *Solanum tuberosum*.

On the basis of previous work done by various mycologists and plant pathologists on Fusaria of potatoes, it was evident, even before the monographic work of Appel and Wollenweber (1910), that the potato is a host of a number of different species of Fusarium. At the same time the descriptions of these organisms were, almost without exception, so confusing, and the organisms as a rule were apparently so variable, that there was no sure way of identifying a Fusarium isolated from potato with a previously described Fusarium even of the same host. Such a state of affairs led Smith and Swingle (1904:50) to make a general statement as follows: "Many specific names have been given to *Fusaria* growing on the potato, and while some of these names may stand for distinct forms, this is not at all certain. Most of these names undoubtedly are synonyms, and for the purpose of this paper all are regarded as such."

On the other hand, Lindau (1908) and others continued to believe firmly that there were different Fusaria of potatoes, and that *Fusarium oxysporum* as described by Smith and Swingle is nothing else than a "Mischart."

Whether more than one species of Fusarium occurs on this host and, if more than one, on what basis they could be separated, was then the question which in the opinion of the writer needed to be definitely settled before any pathological work with these organisms could be properly done. This involved the accumulation of as many different strains of the Fusaria as was practicable, from all available sources, and their comparison in pure culture on various suitable media and under the same conditions of growth. On this basis the work has been carried on since the autumn of 1911.

[1] Presented to the Faculty of the Graduate School of Cornell University as a major thesis in partial fulfillment of the requirements for the degree of doctor of philosophy.

When the work was well under way and it became apparent that there are indeed a considerable number of species of Fusarium, it came to the writer's knowledge that the same thing was definitely proved, at least for European conditions, by Appel and Wollenweber (1910) in their *Grundlagen* (page 105), in which they state that most of the Fusaria described by them were isolated from the potato, mainly from the tubers. Since then this work has been continued with still greater confidence in its underlying principles, but now mainly in order to verify the European findings for the American conditions.[2]

All cultures of the Fusaria were obtained by isolations made from diseased parts of the potato plant, mainly from tubers received from pathologists in nearly every experiment station in the United States. Of all the strains of the Fusarium-like organisms thus obtained, over one hundred and twenty organisms at first seemed to differ in some way or another. After a careful comparative study of all these strains, more than half of the number proved to be identical with others.

Some of the remaining organisms were identified with several Fusaria described by Appel and Wollenweber (1910), by Jamieson and Wollenweber (1912), and by Wollenweber (1913, b and c). These are as follows:

Fusarium affine Faut. et Lamb.
F. coeruleum (Lib.) Sacc.
F. dimerum Penz.
F. discolor Ap. et Wr.
F. Martii Ap. et Wr.
F. metacroum Ap. et Wr.
F. oxysporum Schlecht., as described by Wollenweber
F. radicicola Wr.
F. Solani (Mart. p. par.) Ap. et Wr.
F. subulatum Ap. et Wr.
F. trichothecioides Wr.

Still other organisms were found to be very closely related either to some of the species named above or to certain other species, at the same time differing sufficiently from them to be separated on a con-

[2] The general discussion of the genus Fusarium was known to the writer before he began his work, when in the summer of 1911 Dr. Jensen received the *Grundlagen* and now and then read parts of it to the writer. Having no idea that Appel and Wollenweber were working mainly with the Fusaria of the potato, the writer did not study their work thoroughly as early as he should have.

servative basis from those species. These organisms were then designated as new varieties of the following old species:

Fusarium caudatum Wr. (one new variety)
F. culmorum (W. Smith) Sacc. (one new variety)
F. discolor Ap. et Wr. (one new variety)
F. falcatum Ap. et Wr. (one new variety)
F. Martii Ap. et Wr. (two new varieties)
F. metacroum Ap. et Wr. (one new variety)
F. oxysporum Schlecht. (three new varieties)
F. redolens Wr. (one new variety)
F. Solani (Mart. p. par.) Ap. et Wr. (two new varieties)
F. subulatum Ap. et Wr. (one new variety)
F. udum (Berk.) Wr. (one new variety)

The remaining organisms of the genus Fusarium were then named as new species and their varieties. It is probable that at least some of them have been previously described, but the descriptions given are so incomplete that any reasonable identification is doubtful. The matter of identification is discussed on another page.

Besides the Fusaria, several organisms were isolated in the course of the work which more or less closely resemble Fusarium though belonging to a different genus (Ramularia) of the Hyphomycetes. As these organisms are often found on the potato and are easily confused with species of Fusarium, they are treated here, but of course under their proper generic name.

On the whole the work, with a few exceptions, fully verifies the principles laid down by Appel and Wollenweber (1910). The chief exceptions are as follows: (1) The Fusaria as such can be distinguished on almost any medium, including artificial media, provided that the medium is not extremely poor or rich in food materials and also provided that the moisture supply in the medium is well regulated. (2) The microconidia should be recognized as a special kind of spores because of their importance in classification of these fungi. Though microconidia genetically do not represent a separate kind of spores, nevertheless their typical absence for certain closely related Fusaria, as well as their typical presence for others, is characteristic. Besides, whenever they are present they have a constant and often distinctive type of their own. (3) No typical core-

mial nor typical pionnotal form of fructification was observed in any of the true Fusaria, though types of fructification resembling those forms more or less closely were common.

SCOPE OF WORK

The work was confined to a study of the Fusaria as such, that is, without any consideration of the possible perfect forms.[3] The study was centered mainly on the characters that seem to be most important and practicable for a natural classification of these organisms. Thus, especial attention was paid to the presence and type of each kind of spores (micro- and macroconidia and chlamydospores). Type of color production was found to be next in importance. Type of fructification and of conidiophores, size of spores, presence or absence and kind of sclerotia, and rate and character of colony growth, were also found to be of more or less considerable importance for differentiation of the species.

Some work has been done on the action of these organisms under different environmental conditions and also with respect to their pathogenicity. In regard to the latter the following four facts should be mentioned:

1. Extensive inoculations of potato plants with all the Fusaria presented here yielded negative results and would indicate that they are not wilt producers.[4]

2. Several series of inoculations of potato tubers showed (a) that a considerable number of the Fusaria can cause more or less rapid decay of the tubers, and (b) that most of the Fusaria readily produce rot only after the tubers begin to sprout.

3. The commonest rot-producing organism, at least in eastern United States, is *F. coeruleum* (Lib.) Sacc.

4. The inoculations into tubers seem to indicate that some species widely different morphologically may act similarly pathologically, and that other species very closely related from the morphological standpoint differ very widely in their pathogenicity.

The other results of this phase of the work will be mentioned only in

[3] In this study no special attempt was made to discover the perfect stage of any of these organisms. At the same time it is to be noted that under the condition of the work when a considerable number of "natural" as well as "artificial" media were used, none of the Fusaria produced a perfect stage.

[4] The writer does not mean by this statement that the Fusaria actually never produce wilt of potatoes, because it is possible that the negative results were due to lost virulence of the cultures used or to some other important factor that escaped attention.

those instances in which different action under different environment is of importance in identification.

SOURCE AND METHODS OF ISOLATION

Most of the species of Fusarium and related organisms presented here were isolated from potato tubers affected with dry or soft rot. A number of isolations were made also from discolored fibro-vascular bundles of potato tubers and from stems of wilted potato plants. A single organism, *Fusarium metacroum* var. *minus*, was isolated from a spot on the surface of a half-dead potato stem.

In a few cases the isolations were made by means of poured plate dilutions, but in the majority of cases they were made from affected tissues of the host. The affected part of the host was first thoroughly wiped with a piece of cheesecloth moistened in 0.1 per cent solution of corrosive sublimate, and then the "skin" was peeled off just above the affected part, or the diseased part of the plant was broken open so that the spot from which the isolation was to be made was not touched even with sterile utensils.[5] Four or five small fragments of diseased tissue were cut out with a sterile scalpel and transferred with a sterile needle to cooled poured plates of a suitable medium. When a rotted tuber showed a noticeable difference, in color or otherwise, in different regions of the decayed part, a separate set of plantings was made from each region. The actual isolation of more than one Fusarium from a single tuber shows that this precaution was, at least in some cases, worth while.

Several days after plantings were made, if any fungi were present they usually had made considerable growth and often allowed a preliminary macro- and microscopic comparison of the isolated organism with any others of the same series of isolations or of former ones.

In case a fungus thus obtained was different in some way[6] from the others, two transfers into test tubes of a suitable medium were made for further study. In order to make a culture from the start as pure as

[5] Small instruments and glassware may be sterilized conveniently by storing them in a jar of 80-per-cent alcohol. When ready to use the excess alcohol is burned off by passing the instruments through a flame. When so treated the instruments are sterile, perfectly dry, and not too hot for immediate use.

[6] Rate and character of growth, color, and type of spores were at first almost the only characters on which these organisms were judged.

possible, these transfers were made from the very margin of the colony. But if in a colony there were apparently two or more organisms growing together, this method would invariably lead to isolation of the rapidly growing one and loss of the slower-growing one. In order to save the latter also, the plates with original plantings were kept for a long time after the first transfers were made, and now and then dilutions were made from the old colonies. In the majority of cases this work was useless, but in two cases there were isolated very slow-growing fungi — *F. dimerum* var. *Solani* and *F. udum* var. *Solani* — which otherwise would have been missed.

The cultures obtained by transfers from original plantings seemed to be, and usually were, pure cultures from the start. Nevertheless it was evident that some method of obtaining cultures from single spores must be employed before a comparative study of the organism could be profitably begun.

In those few instances in which a culture did not produce any spores for a long time and which appeared to be a mixture of more than one fungus, an attempt was made to separate the organisms by the mere planting of a small bit of the fungous growth in the center of a newly poured plate. In only one case was the result satisfactory. This was when a bit of mixed growth of *F. arcuosporum* and *Ramularia Magnusiana*, on being planted in a plate, produced from the start on one side a pure growth of one fungus and on the other side a pure growth of the other fungus. In all the other cases a culture, if transferred into several different media, sooner or later always produced a sufficient number of spores; and in order to obtain a pure culture the poured-plate method of dilution was invariably employed.

Considerable economy of time and labor was effected by placing a number of separate drops of sterile water in a sterile plate. By transferring spores from drop to drop, a drop is soon secured in which the number of spores is such that a small loopful transferred to a drop in another plate will contain only thirty or forty spores. The melted and properly cooled medium is then poured into the plate, and distribution of spores is effected by giving the plate a rotary motion before the medium has hardened.

The first observation of the dilution plates was made about a day later. At this time most of the spores had germinated and could be observed

from the bottom of the plate with comparative ease. When a single spore at some distance from the others was located, it was marked with a circle of india ink. In this manner several spores were marked and the plate was left for another day, after which the colonies were usually large enough to be observed with the unaided eye. Transfers could then be made easily and surely. These transfers have been kept as the stock cultures. The dilution plates from which stock cultures were obtained were kept for several weeks longer, in order to see whether all the colonies were alike.

In only three cases, after the first dilution, did there appear to be different colonies present in the same separation plates. In one of these cases this was the result of a mixed growth of two distinct fungi. It is of some interest to note here that the mixed culture appeared to be a fine specimen of a pink fungus. On dilution it gave rise to a brick red fungus, *F. metacroum*, and a white one, *F. diversisporum*. In the other two cases the fungi obtained from the differently appearing colonies represented most closely related organisms which never were isolated again, but which nevertheless remain distinct from each other. Whether they represent mutations, fluctuations, or mere chance coexistence of the two actually different organisms, is a matter yet undecided. They are tentatively designated as two different varieties — *F. bullatum* var. *roseum* and *F. arthrosporioides* var. *asporotrichius*.

The stock cultures were subsequently repeatedly rediluted, and, as was to be expected, almost invariably[7] every dilution plate showed all the colonies from the same stock culture to be alike.

As it is not possible to use a high-power objective with the ordinary petri dish, and as single spores of some of the species are very difficult to locate because of their size and lack of color, there was always the possibility that some of the cultures which seemed to be pure were really mixtures, for it is a well-known fact that the spores of many fungi often cling together tenaciously. In order to make absolutely sure that pure cultures were being dealt with, the further precaution was observed in 1913 of locating single isolated spores with a high-power objective and

[7] Only two exceptions were observed: (1) In the case of *F. metacroum* var. *minus* among characteristic red colonies, there appeared one colorless colony. For a while the absence of color was a constant character, but later the color was produced again. (2) In the case of *F. diversisporum* among colonies with high aërial mycelium there was a colony almost without aërial mycelium. In subsequent generations the aërial mycelium reappeared almost to the same extent as originally.

securing cultures from them.[8] The cultures thus obtained were in all respects similar to the original stock cultures, thus confirming the reliability of the poured-plate dilution.

CULTURE MEDIA

It is a well-known fact among mycologists that under different environmental conditions many fungi vary considerably in their macro- and microscopic characters. One of the most important factors in variability is the substratum. According to Thom (1910), certain characters in Penicillia appear only when the fungi are grown on a certain medium. Other instances of a similar nature might be cited.

Because of this variability of many fungi with variation in the substratum, it seemed indispensable in this study of Fusaria to use a number of different media in order to find the extent of the variability in the Fusaria and to determine, if possible, which media could be most profitably employed in this kind of work.

The so-called " natural " media, as well as artificial media, were used.[9] Those employed most extensively were potato tuber and stem plugs, and hard agars of potato, lima bean, and oat. For the study of color production, from 8 to 10 per cent of sugar (glucose) was added to one of the above agars, usually to potato agar. In all other cases the agars were used without glucose or with a small amount of it (0.5 per cent). In a few instances the agars were more or less acidified by the addition of small quantities of lactic or citric acid (from 1 to 3 drops of 50-per-cent acid

[8] The method employed was as follows: A number of drops (from eight to ten) of sterilized potato broth were placed on a sterile glass slide. Dilution transfers were made from drop to drop until such a dilution was secured that on removing a small droplet on the flattened end of a platinum needle it was found by microscopic examination that in many cases a single spore could be obtained. From such a drop nine transfers were made to a sterile, but somewhat greasy, cover glass. By placing the cover glass over a tubular glass cell or a van Tieghem cell, each individual droplet could be examined with a high-power objective. Droplets containing no spore or more than one spore were wiped off at once with a pointed piece of blotting paper. In thus removing spore droplets, the spores also were invariably removed. Sterile water was placed in the bottom of the cell and the cover glass was sealed to the cell with sterile water. The cells were then placed in a moist chamber for about twelve hours, and by this time the spores had usually germinated and could be observed with much greater ease. This observation was almost indispensable in the case of those species that produce numerous minute microconidia, as any such could be easily detected at this stage. Only two or three droplets bearing single unmistakably germinating spores were allowed to remain on the covers. At the end of twenty-four hours more, the growth of mycelium from the single spores was usually sufficient to be seen with the unaided eye and could be transferred readily with a finely pointed needle to a suitable medium.

[9] The media used were: (1) Natural — potato, bean, and pea stems; rye straw; canes of red raspberry; grains of rye, wheat, oat, barley, corn, and rice; corn meal and oatmeal; whole potato tubers and plugs of potato tuber. (2) Artificial — potato, lima-bean, oat, corn, and nutrient agars (hard and soft, from 1 to 3 per cent agar, neutral and more or less acidified, without and with different amounts of glucose).

to 10 cubic centimeters of the medium); otherwise they were used as they were after the process of cooking and sterilizing.[10]

The method of preparing all natural media was very simple. It consisted in cutting suitable pieces, tubing, and sterilizing in an autoclave for twenty minutes at fifteen pounds pressure. Enough distilled water was added to the tubes to keep the cultures in good growing condition for from three to four weeks, the exact amount, of course, depending on the size and succulence of the material used. The decoctions that were most commonly used were prepared in the following ways:

Potato decoction.— Two hundred grams of peeled potato tubers were sliced, 1000 cubic centimeters of distilled water was added, and the material was cooked for about forty minutes in a double boiler. The clear liquid was then decanted and the volume restored.

Lima-bean and oat decoctions were prepared by soaking 100 grams of ground lima beans or oats in 1000 cubic centimeters of distilled water at 60° C., in an incubator for an hour. The liquid was separated by straining through cheesecloth and the volume was restored to the original 1000 cubic centimeters.

Corn meal decoction was prepared as described by Shear and Wood (1913); that is, from about 35 to 40 grams of corn meal were treated in the same way as 100 grams of lima beans or oats in the preceding case.

For the artificial media, to 1000 cubic centimeters of a decoction were added agar (10, 15, or 30 grams, these amounts corresponding respectively to soft, medium, and hard agar) and glucose (0 to 100 grams), and the whole was cooked in a double boiler over a free flame for an hour, or, more exactly, until all the agar was well dissolved. The liquid was then tubed, plugged, and sterilized in the same way as were the natural media.

At the present stage of this work, it seems that all the labor spent on using so many different media was more or less wasted. It seems that the same results could as well be obtained with but a few good media, preferably the following: a hard oat agar (without glucose), a stem and tuber plug, and a potato agar with about 5 per cent of glucose. All other media used in the course of this work did not prove to be of any specific value, and at the best gave the same results that were obtained with those just named.

[10] When an acid was added to an agar this was done after the medium was sterilized, the medium then being quickly cooled. This quick cooling was necessary because otherwise an acidified agar often would not solidify as well as it should.

For determination of the color of the substratum and also for study of the colony growth, it would perhaps be best to use poured plates with about 10 cubic centimeters of a clear agar. In this work potato hard agar with from 5 to 10 per cent of glucose was almost exclusively used for this purpose. For the study of other characters, in most cases cultures were made in common test tubes.

EFFECT OF VARIOUS MEDIA ON DIFFERENT CHARACTERS OF FUSARIA

In the course of this work it was observed, in partial confirmation of the statement by Appel and Wollenweber (1910:12–23), that certain media affect fungous growth more or less characteristically. A medium too rich in nutrients, especially in glucose, usually gives cultures with more or less abnormal spores, the abnormality showing itself in a too dense granulation of the protoplasm, in more or less considerable swelling of the spore cells, and often in abnormal septation, size, and shape.

Media rich in glucose usually increase the density of color produced by these fungi, and often also change its character. For example, a pink fungus, *F. arcuosporum*, is turned to a clay-colored one; or the fungus *F. angustum*, which is colorless or nearly so, is turned to a more or less bright purplish-vinaceous one; and so forth.

Excess of water in a medium usually leads to comparatively quick degeneration (self-digestion?) of the spores, and, in general, to a shortened duration of the vitality of the culture. Its presence, at least in case of a soft agar as compared with a hard agar, is usually unfavorable for the normal development of aërial mycelium.

A medium comparatively poor in nutrients, such as corn meal agar, seldom gives rise to sclerotia and plectenchymic sporodochia; but in a way it is a good medium for the study of chlamydospores, which are produced here more or less freely and stand out more clearly than in other media.

Whole potato tubers (steamed) often are most favorable for production of large sporodochia; this medium, and also potato tuber plugs (also steamed), show the largest sclerotia.[11]

An agar, especially such a one as oat hard agar, often gives all the forms

[11] See also Wollenweber (1913 a: 25).

of fructification for these fungi, with "normal" spores and more or less typical and brilliant color production.[12]

On the plugs made from stems of different plants, spore production seems to be normal.[13] The spores are of typical and comparatively uniform shape, septation, and size, without too dense granulation of the protoplasm, and with a long duration of vitality. It often is found, however, that on such media spores are less normal than, for instance, on a hard agar.

Presence of the epidermis on the stem and tuber plugs seems to favor production of fewer but better developed sporodochia,[14] and often lessens development of aërial mycelium.

Certain media, such as boiled rice, give a color that is typical for certain related Fusaria.

EFFECT OF LIGHT AND OF REACTION OF THE MEDIUM ON DIFFERENT CHARACTERS OF FUSARIA

As was stated in the introduction, very little systematic work has been done on the ecology of the Fusaria. The few things which have been found by other workers and by the writer, and which have some value in the determination of these fungi, may be summed up briefly as follows:

1. A diffuse daylight may affect color production considerably (Smith and Swingle, 1904:48–49), but in most cases the effect is only slight or there is almost none. It usually intensifies the colors produced by these fungi. A very strong light often makes the colors somewhat duller, especially in the case of Fusaria producing bright red colors, these being turned toward brown hues. No noticeable effect of the light was observed on other characters of these fungi, although Appel and Wollenweber are of the opinion that the spores are of a more normal type in the light than in the dark.

2. According to Appel and Wollenweber the reaction of the medium has an especially noticeable effect on blue colors, which can appear only in a medium of neutral or rather alkaline reaction. The blue color in a medium of an acid reaction will appear as orange. True red colors remain

[12] This observation is apparently in some contradiction to the observations of Appel and Wollenweber (1910:12–13), but indeed it is not so; because, judging by the "artificial" media actually used by them, their observation of unfitness of such media for study of "normal" growth of the Fusaria was based on "soft" agars too rich in sugar. The writer also found that such agars produced abnormal growth.

[13] This was observed first by Appel and Wollenweber (1910), and on this observation mainly they concluded that the only way to study the Fusaria properly is to study them on such "natural" media.

[14] This was first observed by Appel and Wollenweber (1910).

red even in a medium of an alkaline reaction. The observations of the writer, so far as they go, are in full agreement with the above statements; to which it may be added that certain fungi which in a neutral medium produce a grayish white aërial mycelium (*F. sclerotioides*), in the same medium strongly acidified (0.4 per cent by weight of citric acid) produce an aërial mycelium of a pink-vinaceous shade.[15]

It was observed also that acidity of the medium lowers the rate of the fungous growth and makes zonation of the colony more prominent and closer. The retardation of the growth depends on the kind of acid (see also Smith and Swingle, 1904:42, 48) and its concentration; different Fusaria are not affected in the same degree, some tolerating more acid than others (see also Lewis, 1913:238).

THE GENUS FUSARIUM

Appel and Wollenweber (1910:4–12, 23–61) present a very detailed, critical study of the genus, with the following list of synonyms:

Atractium Link pr. p. (1809)
Fusidium Link pr. p. (1816 and 1825)
Fusisporium Link (1824)
Selenosporium Corda (1837)
Fusoma Corda (1837)
Pionnotes Fries (1849)

The description of the genus Fusarium given by these investigators, when other data presented by them are also taken into consideration and using the terminology of Lindau (1905, 1908–1909), may be stated in brief as follows:

Hyphomycetes of Mucedinaceæ-Hyalophragmiæ, Hyalostilbaceæ-Phragmosporæ, and Tuberculariaceæ-Mucedineæ-Phragmosporæ groups, with smooth, not appendiculate, mostly sickle-shaped, acrogenous, noncatenulate conidia.

The genus as delimited by these authors was to include also forms such as *F. dydimum* and *F. Willkommi*, with cylindrical, one-septate spores, and bacilliform, one- to five-septate spores.

The writer has not sufficient material on hand to warrant any change in the above characterization of the genus; but in the course of this work,

[15] The medium used in the instance cited was potato hard agar plus 5 per cent of glucose. The cultures were made in petri dishes.

a true Fusarium never was observed which would produce a typical coremium[16] or a typical pionnotes,[17] that is, the two fruiting forms on the basis of which the genera Atractium and Pionnotes were founded by their authors and which are now reduced to synonymy by Appel and Wollenweber because these investigators find in the Fusaria certain structures resembling these two forms.

That one of these forms, Pionnotes, is a distinct form, and that its characters can be used as a basis in a classification of Fusarium-like organisms, has been shown lately by Wollenweber. After citing *Fusarium* (*Pionnotes*) *udum* and its variety as instances of the Fusaria without "Fusszelle," he (1913 c: 206) says: "Beiläufig bemerkt, bilden solche Fusarien zusammen mit *F. aquaeductum* eine gute Section der Gattung, die ich Eupionnotes nenne wegen des Übergewrichtes dieser Sporenverlagerung."

There is very little doubt that a true coremial form of fructification is quite distinct, and does not occur in the species of Fusarium observed by the writer.

With respect to the present status of the genus Fusarium, some recent changes must be considered here. Wollenweber (1913 a:33) transferred from the genus Fusarium to the genus Ramularia all forms with conidia of *F. dydimum* type when chlamydospores are present.[18] The same author (1913 c:225), somewhat later, also excluded from the genus Fusarium forms with conidia of the type of *F. Willkommi* and transferred them into a new genus, Cylindrocarpon,[19] established for this purpose. Thus, in fact, all forms having cylindrical conidia or conidia with rounded ends are excluded by Wollenweber (1913 c:239) from the genus Fusarium. The genus Sepedonium Link (1809), according to Wollenweber (1913 c: 200), is only a chlamydosporial stage of *Fusarium orthoceras*.

It appears, then, from the study of the Fusarium-like organisms of potatoes (which, on the whole, represent a great diversity of forms) and also from a careful survey of the genus Fusarium as it stands in literature, that the following characters are of generic value:

[16] The terminology which is used here is the same as that of Lindau.

[17] Only one Fusarium-like organism was isolated from potatoes which produces a fruiting layer very similar to a pionnotes (*F. udum* var. *Solani*), but it is very distinct from all the other Fusaria and can be used rather to support than to disprove the above statement.

[18] In those cases in which chlamydospores are not present, Wollenweber says the fungi have a perithecial stage of the genus Mycosphærella.

[19] This genus is to include only those forms for which a perithecial stage has not yet been found. *F. Willkommi* has been connected with *Nectria galligena*.

1. Color of conidia and mycelium, never of a plain gray or black color but mostly of various brilliant hues.

2. Conidia dorsiventral,[20] attenuate, pedicellate,[21] not appendiculate, smooth, normally not constricted at the septa, distinctly three- (or more) septate,[22] acrogenous, not in chains.[23]

3. Conidiophores with single to irregularly whorled branches, never truly dichotomous nor of a strictly penicilla e or verticillate type. The conidiophores, through many times repeated branching or also by growing side by side with other conidiophores, typically give rise to macroscopically observable, dense tufts of conidiophores covered more or less deeply with a somewhat slimy mass of spores. Such fruiting bodies, tuberculate in form (sporodochia),[24] may be with or without a plectenchymic (=pseudo-parenchymic), flat or wartlike base, without any differentiated enclosure.

4. Chlamydospores (endogenous, double-walled, resting bodies) terminal and intercalary, or only intercalary,[25] or none, and produced both by mycelium and by spores.

5. Mycelium composed of hyphæ which are always distinctly, but not closely, septate, and irregularly, never dichotomously, branched, the secondary branches usually thinner than the primary ones; protoplasmic content of the mycelium for the greater part plainly present and usually distinctly vacuolate. The rate of growth in artificial media, when compared with the Fusarium-like organisms studied, is comparatively high.

It must be added here, as a general remark to the characteristics of the genus Fusarium given above, that in this case, as well as in any other attempts at classification of natural phenomena, the boundaries laid down for separation of one group of phenomena from all the rest have only a relative value. Thus an organism may deviate[26] in a greater or less degree in one or a few of the characters given above, and yet, so

[20] This term is used by Appel and Wollenweber (1910).

[21] This term is used by Wollenweber (1913 c). See his key on page 219 of reference cited.

[22] Fusaria-like organisms with one-septate conidia are rare. Two such organisms were isolated from potatoes, and from over one hundred and sixty Fusaria recorded by Lindau (1908-1909: 517 588) only seven are definitely stated to have one-septate conidia; and of these seven at least two are undoubtedly not Fusaria if the changes made in this genus by Wollenweber are considered.

[23] Microconidia may be produced in chains. This is true in case of certain Fusaria of corn and of coniferous seedlings. (See Sheldon, J. L. A corn mold [Fusarium moniliforme n. sp.]. Nebraska Agr. Exp. Sta. Rept. 17: 23-32, fig. 1. 1904.)

[24] The terminology used here is the same as that used by Wollenweber (1913 a: 24, footnote).

[25] The only Fusarium-like fungus isolated by the writer which has only terminal chlamydospores seems not to be a typical Fusarium. (See *F. cuneiforme*, key and description.)

[26] Of course a true Fusarium, evidently, in no case can be of a plain gray or black color (in mycelium and conidia as well), or have non-septate or cylindrical macroconidia with both ends rounded. (In regard to the macro- and microconidia, see page 116.) Its conidia cannot be appendiculate nor its conidiophores of a true verticillate or any other specifically peculiar type.

to speak, be a good Fusarium provided all other characters of this genus are well expressed by the organism.

VARIABILITY IN THE FUSARIA

Many of the morphological and physiological characters of the Fusaria show marked variability, and at first seem to be of such a nature as to discourage any attempt to treat these fungi on a morphological basis. Thus Smith and Swingle (1904:27), in regard to their *F. oxysporum*, say: ".....This fungus showed a number of very striking variations. For this reason it is impossible to give a general description that will hold universally." And after quoting descriptions of eleven old species of Fusarium from potatoes, the authors conclude as follows (1904:51): "Judged by the above descriptions, we have had a half dozen or more species of *Fusarium* in our culture tubes, some of them 'new species,' and yet all were the product of a single spore. This does not mean that there have been in our cultures any very wonderful transmutations of one thing into another, but only that organisms respond to their environment, and that 'species descriptions' of the kind cited have not taken this fact into consideration, and consequently are worthless for scientific purposes. This is not a new idea, but it is a fact to which the attention of systematic mycologists might be directed profitably at frequent intervals."

Sometimes variability, for example in the type of conidia, is so great that a student gives up hope of determining the actual type. Thus Wilcox, Link, and Pool (1913:24) conclude their discussion on the form of the conidia produced by their fungus[27] as follows: "All sorts of stages are shown in the plate, so that each one can judge for himself, as it is possible that one who has studied a great number of species of *Fusarium* will be able to pick out the characteristic form which can be set aside for this particular species."

A great number of instances of variability in this group also could be cited easily from the species presented in this paper. But it will suffice to state here only those instances of variability which are, perhaps, most important and more or less common:

1. The type of the conidium varies in many Fusaria from micro- to

[27] *F. tuberivorum* Wilcox and Link, which according to Wollenweber (1913 c : 206) is identical with *F. trichothecioides* Wr.

macroconidia, and both sometimes are of a very diverse type even within themselves. (See *F. diversisporum*.)

2. Conidiophores often vary from mere minute projections on the side of a hyphal thread to a complex dendroid structure often of a size observable macroscopically.

3. In the Fusaria for which production of sporodochia, plectenchymic stromata, or sclerotia is typical, it sometimes happens that they are not p oduced even under apparently favorable conditions. These structures may vary in size, number, and form.

4. The presence or absence of color is an especially variable character. Changes in type of color may occur, but such changes are only apparent and in all known cases can be explained on the basis of the difference in the reaction of the medium (certain orange-red colors in acid become blue in an alkaline medium), or, when a typical color is a compound one, the change may be due to the preponderance of one or another of its elementary colors.

5. Extent of the development of aërial mycelium, zonation, rate of growth, and character of the margin of the colony, may also vary to a considerable extent.

6. Especially great variation may take place in the relative production of the different types of conidia and chlamydospores.

It might appear at first glance that the variation of these fungi is so great as to leave no firm ground for morphological treatment of the group. And yet the actual situation is far from being so hopeless. First of all, the great majority of the variations mentioned above occur, as did those observed by Smith and Swingle (1904:59), under different environmental conditions; while the variability under identical conditions usually (see also Lewis 1913:225) is very slight. Secondly, the cases of variability cited above are primarily cases of variation between presence and absence of certain characters — which is, after all, of no great importance, because when a certain character is present it is always peculiar to a specific type of organism and thus this organism can be separated from others. Then there are certain Fusaria which under almost any but extreme environmental condition remain nearly the same throughout (as *F. udum* var. *Solani* and *F. cuneiforme*). And finally, the most important character in the classification of these fungi — the type and the shape of the conidia

— is after all sufficiently stable to be used safely in a morphological treatment. Even the size of conidia, when a sufficient number of measurements is made and averaged and when only conidia of the same type are compared, is of rather surprising uniformity and stability. It is believed that every one will agree with these statements after an examination of the data presented here in the descriptions of species.

That Fusaria can be separated on a strictly morphological basis was first definitely demonstrated by Appel and Wollenweber.

RELATIVE TAXONOMIC IMPORTANCE OF DIFFERENT CHARACTERS

Usually the particular organism and the prominence and stability of a given character determines the relative importance of characters in classification. Thus, in certain cases septation of conidia may be considered as the important character. For instance, in the case of *F. dimerum* and *F. affine*, this character distinguishes these two fungi at once from all the other Fusaria, while in most other cases it is not of such importance. Presence of a continuous slimy layer of spores is the important character in the case of *F. udum* var. *Solani* where this type of fructification is especially prominent. Type of microconidia, when they are of typical occurrence and especially when they are of a peculiar type, as in the case of *F. sporotrichioides*, is also a most important character. Type of chlamydospores is an important character in general for dividing the whole genus into sections, but it usually has no specific value; and yet there is a fungus, *F. cuneiforme*, which can be set off from all the rest because of its terminal unicellular chlamydospores. Color may vary considerably, but on the whole its type is stable enough to be of considerable help in dividing Fusaria into sections, and sharp contrasts in color can often be used for specific differentiation.

In general the most useful and evidently sure basis for a natural classification of this group is the shape of the macroconidia.[28] Their dorsiventrality, the form of their apex and their basal cell, and their septation, and also their size, when properly used, are of considerable service in separation of species. The actual working value of each character can be seen from the keys.

[28] Appel and Wollenweber (1910 : 34) and Wollenweber (1913 a : 26) came to this conclusion long before the writer. See also Lewis (1913 : 225).

FORMS OF FRUCTIFICATION IN PURE CULTURES

Spores

The spores in the genus Fusarium are of two kinds: conidia, or acrogenous spores, and chlamydospores, or endogenous resting bodies. The conidia in turn may be divided into two more or less distinct types: (1) macroconidia, sickle-shaped, three- or more septate spores; and (2) microconidia, oval, non- or only one- or two-septate spores.

Before the appearance of Appel and Wollenweber's work (1910) the existence of micro- and macroconidia as two distinct types was more or less generally accepted, but in that work it was concluded (page 29) that there is only one type of conidia. The latter view is, of course, correct so far as the genetic relationship between micro- and macroconidia goes. Nevertheless, the typical presence of microconidia in certain closely related Fusaria and their typical absence in others is characteristic. Besides, whenever they are present they have a comparatively constant and often peculiar type of their own. Thus, they can be used as a good natural basis for classification of these fungi, and for that reason must be considered as a type separate from macroconidia.

In this paper the term *microconidia* is applied to all nonseptate, and seldom to one- and even to two- or three-septate, conidia of a different shape from that of the macroconidia, which are sickle-shaped and usually three- or more septate. Different forms of macroconidia are shown in figure 1 (page 112).

Chlamydospores may be borne on the ends of special lateral branches of the mycelium (terminal chlamydospores), or they may be intercalary. They often are produced in the ends of the conidiophores, in the conidia or in the ends of special branches from the conidia. The chlamydospores are single, in short to long chains or in more or less large clusters. They are of common, though not of general, occurrence, and in a number of Fusaria both terminal and intercalary chlamydospores are present; in some others there are only terminal, and in still others only intercalary chlamydospores have been observed. A number of Fusaria evidently have no true chlamydospores; they may possess structures with dense content, but these structures are not thick, double-walled bodies.

Forms of fructification

Sometimes, as in the case of the conidia on aërial mycelium of *F. trichothecioides*, and also in the sporotrichial form of *F. sporotrichioides*,

the conidia are borne singly and remain thus in the form of a powder. Usually, however, they adhere to the tips of conidiophores for a time, forming balls of variable size. This may be the case with microconidia as well as with macroconidia. In certain Fusaria, such as *F. cuneiforme*, and in all members of the section Martiella, these balls of conidia are especially prominent; but they are very common also in the other Fusaria and therefore cannot be used for specific differentiation.

When there is no room for old conidia to be pushed aside — that is, when the fruiting branches are very numerous and close together — a considerable and continuous mass of spores results; these, when the air is moist, form a roundish, wartlike heap of spores, which, with the conidiophores producing them, is known as a **sporodochium.** When the air is comparatively dry, the spores are pushed up in more or less curled, long, tendril-like columns. This is often observed especially in many cultures on sterilized canes of red raspberry and in stem plugs of other plants.

Often small sporodochia are produced on and strewn all over the aërial mycelium, producing a picture very characteristic for *F. subulatum* and some other Fusaria. In other cases minute and numerous sporodochia are produced very close to or on the surface of the substratum, and when these minute sporodochia are very numerous they form a nearly continuous, slimy layer of conidia. The fructification then resembles a pionnotes and is called here **pseudopionnotes.** In one case a seemingly true pionnotes[29] — that is, a thick, continuous, slimy layer of spores — was observed (in *F. udum* var. *Solani*). A pseudopionnotes may be produced under aërial mycelium which may more or less mask its macroscopic appearance, as in the case of several Fusaria of the section Elegans; but in certain cases there is no aërial mycelium over it, and the pseudopionnotes remains fully exposed and characteristic for certain species. (See *F. metacroum*, *F. falcatum*, and *F. discolor* var. *sulphureum*.)

Mycelial threads in many Fusaria often run parallel and anastomose more or less closely, thus producing a ropelike structure which may come up into the air in an irregular fashion and which also may bear more or less abundant conidia produced on side branches. These ropelike structures then resemble coremia, which are columnar fruiting bodies, typical of the family Stilbaceæ. No true coremia were observed in any of the Fusaria presented here.

[29] The definition is taken from Lindau (1908–1909 : 509).

A stroma, in the sense employed here,[30] is the fungous layer on which aërial structures (aërial mycelium, conidiophores, and spores) are produced. The stroma may consist of more or less loose hyphæ, or it may form a dense pseudoparenchymic (plectenchymic), continuous sheet, fleck, or prominent wart. There are often produced also roundish, more or less wrinkled, often shiny, bodies, resembling true sclerotia. They are of a dark blue color, and among the Fusaria studied in the course of this work they were observed only in certain species of the section Elegans; though according to Wollenweber (1913 a:32) they are very common also in the section Roseum, and are characteristic for one species, *F. sclerotium* Wr., of the section Gibbosum.

METHOD OF STUDY AND PRESENTATION

The method actually employed in this work consisted in the cultivation of pedigreed strains of the various organisms on various natural and artificial media. Almost without exception, all the strains were transferred to a new medium on the same day and the whole set of cultures was kept under the same environmental conditions. In all important cases duplicate cultures were employed. For the inoculum, as far as possible, similar material was used — that is, only mature spores or only aërial or only submerged mycelium. The importance of the same environmental conditions for a comparative study is evident. It applies equally as well to the kind of inocula used, as it was found[31] that often an inoculation made with spores tends to better spore production, and an inoculation with mycelium often results mainly, at any rate at first, in the production of mycelium.

In order to bring all cultures to the same stage of maturity and also to assure their purity, dilutions in poured plates were made again and again for the entire set of the Fusaria (of isolations made by the writer, as well as of the organisms obtained in culture from other sources), and then new transfers were made from colonies about two days old produced in the plates.

In the macroscopical examination of the culture, special attention was given to the presence or the absence, and the character, of aërial mycelium; to the kind of fructification layer (pionnotes-like, sporodochial, and so forth); to the color of spores, of aërial and submerged mycelium, and of

[30] A slightly different definition of stroma is given by Wollenweber (1913 a : 24, footnote).

[31] See Appel and Wollenweber (1910 : 13), and also Lewis (1913 : 209). The same was frequently found to be the case also in the course of this work.

substratum; and to the production of special structures such as plectenchymic stromata and sclerotia.

In the microscopical study, the different types of conidia, chlamydospores, and conidiophores received special attention. The observations were recorded by means of camera lucida drawings[32] and necessary measurements.

When measurements were of any importance,[33] ten conidia (or chlamydospores) were measured and only the average and the extremes of these measurements were recorded. In cases of special variability of the material, records were made of fifteen or twenty spores of each important type of septation and shape.

In making camera lucida drawings, care was taken to picture the apical and the basal ends of the conidia with the utmost accuracy; every kind of conidium occurring in a culture was drawn, but the typical and the exceptional cases, as they appeared, were marked off.

As a rule, measurements and drawings usually were made of the conidia taken from sporodochial or pionnotes-like masses of them, because such conidia on the whole are more uniform and typical for a given organism. Here it should be noted that for the measurements and drawings it is highly important, at least in case of very closely related organisms, to use material analogous in all respects — age, type of fructification, and environmental condition.

The fungi were studied, not only on different media, but also at different stages of their growth. The latter factor is almost as important as the former, because in certain cases, as in *F. angustum*, conidia in the best condition (most regular, and so forth) were observed when the cultures were very young. Some characters, however, become manifest only after a culture has reached a certain stage of maturity. This is often the case with chlamydospores and color production. Sclerotia often appear in comparatively old cultures and continue to grow for some time.

The presentation of the species of Fusarium is based on the following main principles:

All drawings (with only a few exceptions) are intentionally made to the same scale as those of Appel and Wollenweber — thus far the one

[32] All drawings were made from living material mounted in water, and, with a few exceptions, with an oil immersion lens. In order to prevent movement of the spores in water, it is necessary first to use just enough water to keep air from underneath the cover glass, and then to spread around the cover glass some oily substance, as cedar oil, which does not dissolve in water and which does not dry out quickly.

[33] A number of fields should be examined before measuring in order to see the prevailing type, and then measurements of the conidia of the prevailing type should be taken. This leaves much to personal interpretation, but otherwise it would be necessary to take many more measurements.

fundamental work on this subject[34] — so that comparison can be made easily. The drawings represent all types of conidia, abnormal ones included, so that no one may be misled by types actually observed by him and by those given here. This might easily be the case if only normal material were presented, because our understanding of what is normal is very relative, is often too broad, and seldom corresponds to the things as they are. The particular forms that seemed to be normal are indicated by the drawings in figure 1 (page 122).

Usually no attempt was made to represent the structure of the cell content, because it was not considered of taxonomic value. In those few cases in which the structure of the plasma seemed to be characteristic it is shown in a very approximate way.

The microscopical character of the mycelium, so far as observed by the writer, cannot be used for specific differentiation of these fungi; therefore no attention has been given it, either in drawings or in measurements, except in a very few instances when certain striking peculiarities have been so recorded (Figs. 34M and 43L).

In giving measurements of the size of spores, it was considered necessary, first, to give an average size for conidia from a particular culture, as well as the average of the measurements for the entire series of cultures. Thus the measurements have a definite meaning and are comparable with one another, provided the measurements are taken separately for each type of spore.

In arranging the species according to their relationship it was found convenient to follow Wollenweber's example (1913 a:26–27), and divide all the Fusaria into sections. Most of the sections are the same as those of Wollenweber, but because of some organisms presented here that could not be placed in any of his sections, certain new sections have been established provisionally.

In connection with taxonomic study and presentation of the Fusaria, it is necessary to discuss, at least briefly, the conception of the so-called normal culture. The observations of the writer in this regard are principally of the same nature as those of Appel and Wollenweber (1910:21–22) and can be summarized as follows:

1. A culture can be in the state of undevelopment (*Ankultur*) when the growth shows mycelium to the entire exclusion of, or to an abnormally

[34] It is firmly believed that standardization of the subject presented is especially important in the study of this difficult group of fungi.

poor production of, spores; other forms normally present in the culture may also be absent. This state of culture may sometimes exist when a fungus is transferred from a mycelial growth, especially when it is taken directly from host tissues.

2. A culture is considered to be a normal one (*Normkultur*) when all forms typical to the fungus — and especially the most important form, the macroconidia — are abundant, comparatively uniform in size and shape, smooth in outline, and so forth.

3. After a long cultivation on artificial media, a fungus may lose certain characters, such as ability to produce certain color and also its virulence as a parasite. Such a state of culture is that of degeneration (*Abkultur*), and it may be accompanied also by smaller size and abnormal septation of the conidia. (Only loss of color was observed by the writer; the other observations are those of Appel and Wollenweber, 1910:22.)

4. In the first period of growth of any one of the Fusaria, the first conidia produced usually soon begin to produce new conidia, sometimes on minute papillæ located directly on the conidial walls, and sometimes on more or less well-differentiated and well-developed conidiophores, the process often much resembling the budding process in yeasts. In such young cultures the conidia are more or less swollen, their contents are commonly densely granular, and septation is not clear. This period (*Jungkultur*) may last from one to five or more days.

5. After the period just described, the fungus, when in normal condition, produces conidia which remain for a greater or a less length of time, of perfectly smooth outline and with clear septation. At this state of maturity (*Hochkultur*) the conidia are also of most uniform and typical shape and size, and it is the important stage for taxonomic study of these organisms.

6. Finally there comes a period (*Altkultur*) in which the conidia begin to disintegrate through the process of self-digestion, or at least become of less uniform and perfect type, and after a period of time the culture begins to lose its vitality.

These variations in character of the cultures show that only normal and mature cultures must be considered, though the character of other conditions may also give some help in identification. Another point which must be clear from the account given above is that in the study of these fungi they must be grown for a long period of time, under different cultural conditions and from different kinds of material for inocula. Then, after

observation of all the stages, it will be possible to pick out easily the typical and normal one and base judgment mainly on that. Most minute attention must be paid to the shape of macroconidia.

In order to avoid much of the possible confusion in regard to the color production by the fungi, it will perhaps be not out of place to mention again that a convenient standard of colors must be used. Ridgway's (1912) color standards have been used in this work.

IDENTIFICATION OF THE FUSARIA WITH PREVIOUSLY DESCRIBED SPECIES

An identification of the Fusaria of potatoes with Fusaria formerly described as occurring on other substrata and even on potatoes, is in most cases impossible or at least rather doubtful. The species have been described mostly from material as it was collected in nature. After what has been said in the foregoing pages about variability of the Fusaria, about their common occurrence in different, often abnormal, stages, about the necessity of most minute attention to the peculiarity of the shape of the macroconidia, and about the importance of good drawings and of measurements properly made and presented, it can easily be seen what small chance there is of identifying an organism from any typical description of one of these species. The figures are often absent, and when present they are either too schematic or so inaccurate that they might just as well be omitted. Any citation in support of this statement would be superfluous.[35]

There are a number of different Fusaria which agree with a certain description and therefore might be considered as the same species. At the same time the very same organism may have other characters which, if studied alone, would surely set it off as a distinct species. An extensive illustration of this state of affairs is given by Appel and Wollenweber (1910:9–12), but the most impressive case is that of Smith and Swingle (1904:50–51). Therefore, although the literature on the subject was fully examined, especially publications of descriptions supplemented by any kind of illustrations, usually no definite conclusion in regard to identity could be arrived at. Because of this, and also because the most important literature is already listed in a few works on this subject (especially by

[35] Appel and Wollenweber (1910:12) in this connection made the following statement: "Oft blieb uns daher weiter nichts übrig, als neue Namen zu geben und ihnen so genaue Beschreibungen beizufügen, dass nunmehr die Arten immer wieder erkannt werden können."

Appel and Wollenweber in 1910, and by Wollenweber in 1913), this literature is usually not cited and a bibliography is omitted.

The condition of the taxonomic literature on species of the genus Fusarium in general is characterized by Wollenweber (1913 a:41) as presenting "an almost hopeless confusion." The only favorable exceptions known to the writer are the works of Wollenweber, alone and in association with other authors. These works are fully considered here. In fact there is hardly any difficulty in recognizing Fusaria described by Wollenweber. Nevertheless all available cultures of his organisms were grown along with the other Fusaria, and a thorough comparison of living material was made whenever it was necessary.

When this work was actually completed there appeared the work of Lewis (1913) on certain disease-producing species of Fusarium. The work was supplemented also with Wollenweber's list of the names for the fungi studied by Lewis, and also with certain remarks by Wollenweber in regard to the taxonomy of those organisms. It appeared that certain of Lewis's organisms were the same as those isolated by the writer from potatoes. Cultures of four Fusaria, somewhat resembling certain species isolated from potatoes, were obtained by the writer through the courtesy of Dr. Morse, Plant Pathologist in the Maine Agricultural Experiment Station. On comparison these four organisms — *F. pirinum* (Fries) Sacc., *F. conglutinans* Wr., *F. citrinum* n. sp., and *F. argillaceum* (Fries) Sacc.— were found to be distinct from all Fusaria presented here.

SYSTEMATIC ARRANGEMENT OF THE SPECIES OF FUSARIUM OF POTATOES

The natural key to the species and their arrangement in sections,[36] as given here, are in the main similar to those of Appel and Wollenweber (1910:59–60) and of Wollenweber (1913 a:28–32), respectively. Some changes and additions have been made, however, in order to include many new organisms.

Variety is used as the smallest unit in the taxonomic treatment of these fungi. An organism is classed as a variety if it differs from the closely related species in only one character, even though the difference be conspicuous; the same treatment holds with respect to the organisms that differ slightly in a few characters. When the differences are slight, but in several important characters, the organisms are classed as distinct

[36] The term is used by Wollenweber (1913 a: 28).

species. In general it was preferred rather to name a possibly good species as a variety than to raise a mere variety to specific rank.

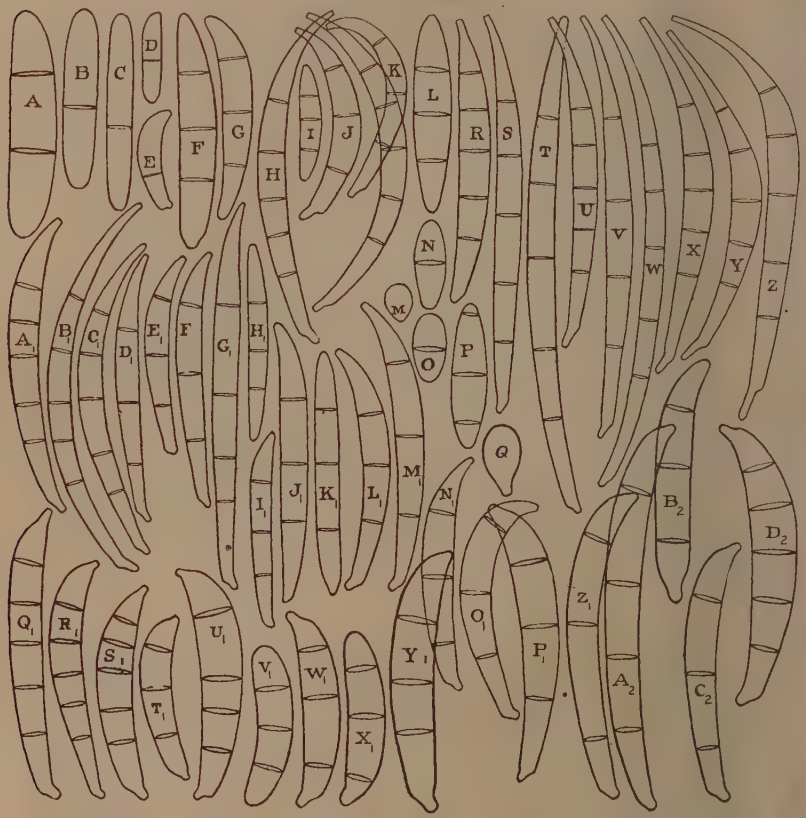


FIG. 1.— *Types of conidia of the species of Fusarium and Fusarium-like fungi found on potatoes.* A, *Ramularia Solani;* B, *R. eudidyma;* C, *R. Magnusiana;* D, *Fusarium affine;* E, *F. dimerum;* F, *F. cuneiforme;* G, *F. udum var Solani;* H, I, J, *F. ferruginosum;* K, *F. sanguineum var. pallidium;* L, M, N, O, P, *F. arthrosporioides;* Q, *F. sporotrichioides;* R, S, *F. arthrosporioides var. asporotrichius;* T, *F. anguioides:* U, *F. biforme;* V, *F. lucidum;* W, *F. subulatum;* X, *F. falcatum;* Y, *F. gibbosum;* Z, *F. caudatum var. Solani;* A_1, *F. bullatum;* B_1, *F. arcuosporum;* C_1, D_1, E_1, *F. truncatum;* F_1, *F. lutulatum;* G_1, H_1, *F. angustum;* I_1, J_1, K_1, *F. orthoceras;* L_1, *F. oxysporum var. resupinatum;* M_1, *F. oxysporum var. longius;* N_1, *F. oxysporum;* O_1, *F. sclerotioides;* P_1, *F. redolens var. Solani;* Q_1, *F. discolor;* R_1, *F. clavatum;* S_1, T_1, *F. subpallidum var. roseum;* U_1, V_1, *F. trichothecioides;* W_1, *F. discolor var. triseptatum:* X_1, Y_1, *F. Solani:* Z_1, A_2, *F. Martii;* B_2, *F. coeruleum;* C_2, *F. striatum;* D_2, *F. culmorum var. leteius. Magnification 1000 times*

DICHOTOMOUS KEY TO THE SPECIES OF FUSARIUM AND FUSARIUM-LIKE FUNGI OF POTATOES

Page

a. Conidia [37] not typically dorsiventral, apex rounded, apedicellate.....RAMULARIA 264
b. Conidia typically one-septate
c. Average diameter of one-septate conidia 4.9 μ.....*R. eudidyma* 264
cc. Average diameter of one-septate conidia 3.9 μ.....*R. Magnusiana* 265
bb. Conidia typically two-septate.....*R. Solani* 267
aa. Conidia typically dorsiventral, apex more or less attenuate, mostly pedicellate FUSARIUM 125
b. Conidia typically one-septate, three or more septa never present..Section Dimerum 125
c. Ventrally straight.....*F. affine* 126
cc. Ventrally curved.....*F. dimerum* 127
bb. Conidia typically three- or more septate
c. Dorsiventrality slight.....Section Ventricosum 128
d. Chlamydospores terminal only.....*F. cuneiforme* 129
dd. Chlamydospores terminal and intercalary.....*F. ventricosum* 128
cc. Dorsiventrality distinct
d. Conidia apedicellate, true pionnotes present..Section Eupionnotes. *F. udum* 131
dd. Conidia pedicellate, true pionnotes absent
e. Conidia with gradually attenuated, pointed apex
f. Conidia prominently broader in the middle, apex long and narrow, most prominently pedicellate.....Section Gibbosum 133
g. Dorsally more or less hyperbolic.....*F. gibbosum* 133
gg. Dorsally more or less elliptic
h. Aërial mycelium poorly developed, fruiting layers in form of a pseudopionnotes.....*F falcatum* 135
hh. Aërial mycelium well developed
i. Conidia typically five-septate.....*F. falcatum* var. *fuscum* 138
ii. Conidia typically five- to seven-septate.....*F. caudatum* var. *Solani* 140
ff. Conidia of about equal diameter for a more or less considerable part of their length, apex not very long
g. Conidia typically five-septate; typical color of conidial masses red, of substratum pink to orange and brown-red; no terminal chlamydospores
h. Chlamydospores absent
i. Microconidia typically absent.....Section Roseum 142
j. Blue sclerotia present.....*F. acuminatum* 142
jj. Blue sclerotia absent
k. Conidia typically in pseudopionnotes; aërial mycelium weakly developed or absent.....*F. metacroum* 143
kk. Conidia typically in distinct sporodochia; aërial mycelium well developed
l. Sporodochia small, borne on aërial mycelium and without plectenchymic base.....*F. subulatum* 147
ll. Sporodochia large, with plectenchymic base
m. Six-septate conidia typically present.....*F. effusum* 151
mm. Six-septate conidia typically absent
n. Five-septate conidia dominant type.....*F. lucidum* 157
nn. Three- and five-septate conidia about equally present, or three-septate dominant.....*F. truncatum* 155

[37] The term *conidia* is used here, in this key and elsewhere, in the sense of macroconidia.

Page

ii. Microconidia typically present, usually spindle-shaped, non- to three-septate.....Section Arthrosporiella 161
j. Six- to seven-septate conidia typically present, at least in pseudopionnotal stage
k. Distinct sporodochia present
l. Substratum and aërial mycelium near it typically of carmine hues, causal layer of aërial mycelium pink.....*F. biforme* 166
ll. Substratum of a clay color, aërial mycelium white.....*F. diversisporum* 161
kk. No conspicuous sporodochia, fruiting layer on moist media commonly in form of a pseudopionnotes.....*F. anguioides* 169
jj. Six- to seven-septate conidia absent.....*F. arthrosporioides* 175
hh. Chlamydospores present, typically intercalary only
i. Microconidia present, pyriform.....Section Sporotrichiella 183
F. sporotrichioides 183
ii. Microconidia absent or not pyriform.....Section Ferruginosum 186
j. Typical macroconidia of about equal diameter for a considerable length, or not prominently broader in the middle, in some cases approaching the subulatum type, much curved
k. Chlamydospores typically only in mycelium
l. Chlamydospores sparse, never in masses nor in long chains..*F. arcuosporum* 186
ll. Chlamydospores typically abundant, commonly in masses of long chains and in clusters.....*F. ferruginosum* 190
kk. Chlamydospores also in conidia or in conidia only.....*F. sanguineum* 193
jj. Macroconidia typically noticeably broader at the middle, not very pointed at the apex, not much curved.....*F. bullatum* 198
gg. Conidia typically three-septate; typical color of substratum vinaceous red to purplish vinaceous; terminal and intercalary chlamydospores present.....Section Elegans 202
h. Conidiophores simple or only slightly branched
i. Average macroconidia 36 μ long.....*F. orthoceras* 202
ii. Average macroconidia 45.6 μ long.....*F. angustum* 203
hh. Conidiophores typically much branched
i. In plate cultures on neutral potato agar producing exposed and distinct pseudopionnotes
j. Color of the pseudopionnotes vinaceous red.*F. redolens* var. *Solani* 205
jj. Color of the pseudopionnotes vinaceous purple.....*F. lutulatum* 209
ii. No exposed and distinct pseudopionnotes in potato agar plate cultures
j. Macroconidia typically somewhat broader toward apex.....*F. sclerotioides* 214
jj. Macroconidia typically not broader toward apex...*F. oxysporum* 220
ee. Conidia with more or less abruptly attenuated apex, rounded or papillate
f. Substratum typically (on glucose agar) carmine red. The color may be yellowish, but never gray, green, nor blue.....Section Discolor 228
g. Conidia non- to three-septate, rounded at both ends, of common type, numerous (those of discolor type usually only few)..*F. trichothecioides* 229
gg. Discolor type of conidia common, and nearly the only type present
h. Conidial masses pale cream to pale pink in color, aërial mycelium well developed and nearly white.....*F. subpallidum* 230

Page
hh. Conidial masses of pale orange to dark chocolate-red in color, mycelium from nearly slightly pinkish to dense carmine red
i. Conidia much broadened toward apex ..... *F. clavatum* 234
ii. Conidia not or only slightly broadened toward apex
j. Average diameter of five-septate conidia from 4 to 4.4 μ ..... *F. discolor* 236
jj. Average diameter of five-septate conidia from 5.8 to 6.8 μ ..... *F. culmorum* 240
ff. Substratum typically (on a neutral or not strongly acid glucose agar) brownish gray, vinaceous red, vinaceous purple, or blue, but never carmine red ..... Section Martiella 244
g. Macroconidia of even diameter or slightly broader toward apex
h. Macroconidia comparatively long and narrow (from 7.4 to 9.3 times longer than broad)
i. Average three-septate conidia from 37 to 49 μ long ..... *F. Martii* 244
ii. Average three-septate conidia from 34 to 35 μ long
j. Pseudopionnotes on an agar typically present, aërial mycelium poorly developed ..... *F. striatum* 255
jj. Pseudopionnotes on an agar typically absent, aërial mycelium well developed ..... *F. radicicola* 257
hh. Macroconidia comparatively short and broad (only about 5.5 times longer than broad) ..... *F. Solani* 251
gg. Macroconidia typically somewhat broader toward basal end ..... *F. coeruleum* 260

DESCRIPTIONS OF SECTIONS, GENERA, SPECIES, AND VARIETIES

FUSARIUM Link

Link, Mag. Ges. nat. Freunde 3:10. 1824. Saccardo, Syll. Fung. 4:694. 1886. (Cf. Appel. O., and Wollenweber, H. W., Arb. K. biol. Anst. Land- u. Forstw. 8:60–61. 1910. Wollenweber, H. W., Phytopath. 3:24–50, 197–240, fig. 1, Pls. I and III. 1913; Ber. deut. Bot. Gesell. 31:17–34. 1913. Journ. Agr. Research 2:251–285. 1914.)

Hyphomycetes, with from hyaline to bright, but never plain gray nor black, conidia and mycelium; conidia sickle-shaped, septate (usually 3- or more septate), apically pointed, mostly pedicellate, not appendiculate, noncatenulate; conidia scattered over substratum, in pseudopionnotes or in sporodochia, the latter without or with from flat to wartlike plectenchymic substratum, and always without any differentiated enclosing or surrounding structures; conidiophores from simple to irregularly verticillate.

I. Section Dimerum n. sec.

Conidia dorsiventral, 1–septate; chlamydospores may be present.

This section is proposed in order that Fusaria with 1–septate conidia may be included. The two species of this section are comparatively

slow-growing fungi, with hyaline or nearly hyaline mycelium and from hyaline to orange-colored conidia. They appear to differ in many ways from typical Fusaria, but the differences are not sharp enough to warrant transferring them into another genus.

1. *Fusarium affine* Faut. et Lamb. (Figs. 1D and 2)

Fautrey, F., and Lambotte, E., Espèces nouvelles ou rares de la Côte-d'Or, Rev. Myc. Fr. 18:68. 1896. Saccardo, Syll. Fung. 14:1125. 1899.

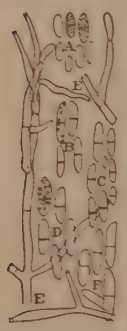


FIG. 2.—*Fusarium affine.* A, *Conidia from 35-days-old culture on slightly acidified potato agar;* B, *conidia from 7-days-old plate culture on hard potato agar;* C, *conidia from 74-days-old culture on red raspberry cane plug;* D, *conidia from 4-days-old culture on hard lima-bean agar;* E, *conidiophores from various media;* F, *conidia from 5-days-old culture on nutrient agar*

Conidia straight, somewhat dorsiventral near apex, apedicellate, typically 1–septate, 10.2 x 2.8 (9–11.4 x 2.6–3) μ, usually in a continuous smooth or slightly roughened, slimy layer, from hyaline to pale salmon-colored on a glucose agar; conidiophores from simple to sparingly branched, septate; mycelium hyaline; no chlamydospores.

Hab. In tubers and stems of *Solanum tuberosum*, in greenhouse soil, New York.

This organism was repeatedly isolated from various sources such as discolored fibrovascular bundles of potato tubers, from the base of wilted potato stems, and from soil. Its size is exactly the same as that given by Wollenweber (1913 c:229) for the conidial stage of *Mycosphaerella Solani* (E. et E.) Wr. Wollenweber's illustrations (Plate XXI, fig. N) are also much the same, and he considers *F. affine* Faut. et Lamb. as the conidial stage. The strain studied did not show any perfect form in culture, although it was grown for more than a year and on various media. This organism can be at once distinguished from all the other Fusaria by its minute, 1–septate, nearly straight conidia and its inconspicuous, slow growth.

For a fuller presentation of its septation and size the following detailed measurements are given:

On red raspberry cane plug, culture seventy-four days old:

Conidia: 0–septate, 45 per cent, 7 x 2.2 (3.5–9 x 1.7–2.6) μ
1–septate, 55 per cent, 9 x 2.6 (6–12 x 2–3) μ

On hard lima-bean agar, culture four days old:
Conidia: 0–septate, 40 per cent
1–septate, 60 per cent, 10.2 x 3 (9–11 x 2.8–3.8)μ

On nutrient agar, culture six days old:
Conidia: 0–septate, 10 per cent
1–septate, 90 per cent, 11.4 x 2.8 (8.7–13 x 2.4–3.5)μ

Average of the above measurements:
Conidia: 0–septate, 32 per cent, 7 x 2.2μ
1–septate, 68 per cent, 10.2 x 2.8μ

The size of the spores of *F. affine* as given by Saccardo (10–15 x 4μ) differs somewhat from the above, but the description otherwise is so much the same that the organisms can be considered identical.

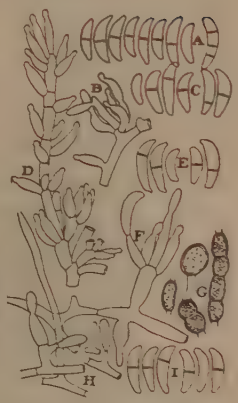


FIG. 3.—*Fusarium dimerum*. A, *Pseudopionnotal conidia from 70-days-old culture;* B, *conidiophore,* C, *pseudopionnotal conidia, from 19-days-old culture on slightly acidified hard potato agar;* D, *conidiophore from 70-days-old culture on potato stem plug;* E, *conidia,* F, *conidiophore, from 43-days-old culture on hard lima-bean agar with 2 per cent glucose;* G, *chlamydospores;* H, *conidiophores,* I, *conidia, from 21-days-old culture on hard lima-bean agar*

2. *Fusarium dimerum* Penz. (Figs. 1E and 3)

Penzig, O., Michelia 2:484. 1882. Saccardo, Syll. Fung. 4:704. 1886. Lindau, Rab. Krypt. Fl. Pilze 9:566. 1910. Appel and Wollenweber, Arb. K. biol. Anst. Land- u. Forstw. 8:37, text figs. 2 and 4. 1910.

Conidia lunar, somewhat pedicellate, typically 1–septate, 13 x 3.3 (12.5–13.5 x 3.3–3.4)μ, often also 0–septate, rarely 2– or 3–septate, borne singly on the mycelium or forming a more or less continuous slimy layer, from hyaline to cinnamon-buff on glucose agar; mycelium from hyaline to about the color of the conidial masses; chlamydospores intercalary, in mycelium.

Hab. On tubers and stems of *Solanum tuberosum* in Germany and in Minnesota (U. S. A.), and on fruits of *Citrus medica* in Italy.

The fungus is easily distinguished from all the other Fusaria by its lunar, minute, 1–septate conidia. It was isolated by the author only once, from a superficial dry rot of potato tuber received from St. Paul, Minnesota.

The measurements of the conidia in detail are as follows:

On hard potato agar, slightly acidified, culture eighteen days old:
Conidia: 0–septate, 3 per cent
1–septate, 97 per cent, 12.5 x 3.4 (10–18 x 2.9–4.1)μ

On hard lima-bean agar with 2 per cent glucose, culture forty-three days old:
Conidia: 0–septate, 12 per cent, 10 x 3.8μ
1–septate, 88 per cent, 12 x 3.3 (10–18 x 3–3.5)μ

On hard lima-bean agar, culture twenty-one days old:
Conidia: 0–septate, 27 per cent, 11.5 x 3.2 (9–14 x 2.9–3.5)μ
1–septate, 73 per cent, 12.5 x 3.3 (10–17 x 2.9–3.9)μ

Average of the above measurements:
Conidia: 0–septate, 14 per cent, 10.8 x 3.5μ
1–septate, 86 per cent, 12.8 x 3.3μ

The organism studied is so much the same as *F. dimerum* originally described by Penzig, that it is considered identical. A similar organism is also reported as occurring on potato in Germany (Appel and Wollenweber, 1910:37). The only peculiarity of the organism which either was not observed or was not present at all in the original *F. dimerum* is that the septum in the conidia of the organism studied is often and conspicuously acentric.

II. SECTION VENTRICOSUM Wr., Phytopath. 3:32

Conidia only slightly dorsiventral, somewhat wedge-shaped, broader toward base, apex somewhat rounded, apedicellate, typically 3–septate; no sporodochia; chlamydospores variable,[38] always present.

3. *Fusarium ventricosum* Ap. et Wr.

Wollenweber, H. W., Phytopath. 3:32, fig. 1, A and V. 1913.

Wollenweber describes this species as follows: "Conidia never formed in sporodochia, brownish-white to cream-colored, 3–septate, 29–37 x 5.75–7.5μ; conidiophores bostryx-like or irregularly branched, chlamydospores like those of the section Elegans. Wound parasite, ... found in Europe. Inhabits also *Beta vulgaris*."

The organism was neither isolated nor studied by the writer.

[38]According to Wollenweber the chlamydospores are of Elegans type, that is, terminal and intercalary, 0– to 1– or more septate. In order to include *F. cuneiforme* it was necessary to alter the characterization of the chlamydospores in this section.

4. **Fusarium cuneiforme** n. sp. (Figs. 1 F and 4)

Conidia only slightly dorsiventral, more or less wedge-shaped, broader toward the base, with apex somewhat rounded, apedicellate, typically 3–septate, 34.7 x 5.6 (30–41 x 5.6–6)μ, often 0– to 2–septate, in false balls, from hyaline to cream-colored; no sporodochia; aërial mycelium hyaline, in a high tuft in center, and short, distinctly zonate, outside; chlamydospores from smooth to very distinctly warted, sometimes surrounded with a gelatinous capsule, terminal only, typically unicellular, 8.2 x 7.6 (7.6–8.5 x 7.3–8.1)μ.

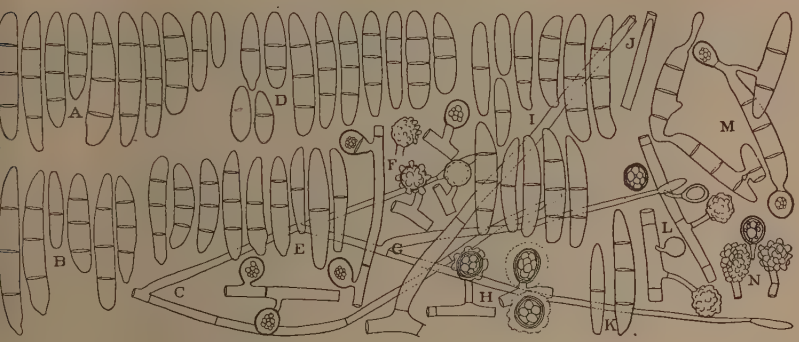


FIG. 4.— *Fusarium cuneiforme.* A, *Conidia from false balls of 16-days-old culture on slightly acidified hard potato agar;* B, *conidia from false balls from 10-days-old potato agar with 0.5 per cent glucose;* C, *conidiophores,* D, *conidia, from a thin layer of 73-days-old culture on red raspberry cane plug;* E, *conidia from confluent thin mass of false balls of 64-days-old culture on hard bean agar;* F, *terminal chlamydospores,* G, *conidiophore, from 34-days-old culture on hard lima-bean agar;* H, *terminal chlamydospores of 16-days-old culture on slightly acidified hard potato agar;* I, *conidia,* J, *tips of conidiophores showing beginning of production of new conidia, from 34-days-old culture on hard lima-bean agar;* K, *conidia,* L, *terminal chlamydospores, from 26-days-old corn agar;* M, *anastomosis, and chlamydospore producing conidia from 34-days-old culture on hard lima-bean agar;* N, *terminal chlamydospores from the same culture*

Hab. The fungus was isolated from soft rotted potato tubers received from Auburn, Alabama, and from Atlanta, New York, always in association with bacteria and other fungi.

Differs from *F. ventricosum* Ap. et Wr. mainly in typically 0–septate chlamydospores which are terminal only. There seems to be some difference also in the shape and size of the conidia, which here are somewhat more slender.

Latin description.—Conidiis parum dorsiventralibus, plus minusve cuneiformibus, deorsum latioribus, apice subrotundato, apedicellatis, typice 3–septatis, 34.7 x 5.6 (30–41 x 5.6–6)μ, 0–2–septatis, globis falsis, ex hyalino "cream color" (R); nullis sporodochiis; aerio mycelio hyalino, medio alte cristato, extra brevi et distincte zonato; chlamydosporis levibus vel maxime distincte verrucosis, interdum capsula gelatinosa cinctis, tantum terminalibus, typice unicellularibus, 8.2 x 7.6 (7.6–8.5 x 7.3–8.1)μ.

Hab. Fungus ex tuberibus mollibus putridisque Solani tuberosi ab Auburn, Alabama, et Atlanta, New York, Amer. bor. receptis, semper una cum bacteriis aliisque fungis, sejungebatur.

The measurements of conidia on different media are as follows:

On slightly acidified hard potato agar, culture sixteen days old:

Conidia: 0–septate, rare, 16 x 4μ
1–septate, rare, 21 x 5.2μ
2–septate, 1 per cent, 24 x 5.6 (20–32 x 5.2–5.8)μ
3–septate, 99 per cent, 35.5 x 6 (24–44 x 4.7–7.5)μ

On red raspberry cane plug, culture seventy-three days old:

Conidia: 0–septate, 12 per cent, 14 x 5.9 (6.5–17 x 5–6.5)μ
1–septate, 34 per cent, 19 x 6 (15–27 x 4.8–7)μ
2–septate, 11 per cent, 33 x 5.9 (20–40 x 5.2–6.5)μ
3–septate, 43 per cent, 33 x 5.9 (20–40 x 5.2–6.5)μ

On hard potato agar, culture twenty-five days old:

Conidia: 1–septate, rare
3–septate, 100 per cent, 35 x 5.8 (24–48 x 5–6.5)μ

On hard lima-bean agar with 2 per cent glucose, culture sixty-four days old:

Conidia: 0–septate, 4 per cent
1–septate, 64 per cent, 25 x 4.9 (12–41 x 3.5–6.5)μ
2–septate, 22 per cent, 28 x 5.5 (23–32 x 4.8–5.9)μ
3–septate, 10 per cent, 30 x 5.6 (24–38 x 4.8–6.2)μ

On hard lima-bean agar, culture thirty-four days old, advanced part of colony growth:

Conidia: 0–septate, rare
1–septate, 17 per cent
2–septate, 7 per cent
3–septate, 76 per cent, 31.5 x 6 (27–41 x 5.2–7.6)μ

On same culture as above but from an old part of the colony growth:

3–septate, 70 per cent, 41 x 6 (36–46 x 5.2–7.6)μ

Average of the above measurements:

Conidia: 0–septate, 3 per cent, 15 x 5μ
1–septate, 23 per cent, 21.3 x 5.4μ
2–septate, 8 per cent, 26 x 5.45μ
3–septate, 66 per cent, 34.7 x 5.9μ

III. SECTION EUPIONNOTES Wr., Phytopath. 3:38, 206, 219

Conidia dorsiventral, apedicellate, nearly cylindrical for the largest part or slightly broader toward apex, typically 3–septate, in true pionnotes; terminal and intercalary chlamydospores present. Differs from all the other sections of Fusaria by true pionnotal fruiting form.

5. *Fusarium udum* (Berk.) Wr.

Syn. *Fusisporium udum* Berk., Ann. Mag. Nat. Hist. 6:438, Pl. XIV, fig. 28. 1841.
Pionnotes uda (Berk.) Sacc., Syll. Fung. 4:726. 1886.

Cf. Wollenweber, Phytopath. 3:38 (footnote), 219 (key), Pl. XXI, figs. R and S.

According to Wollenweber's data and figures, the conidia are dorsiventral with somewhat rounded apex, apedicellate, typically 3–septate, about 33–45 x 3.5–4μ, sometimes 4– or 5–septate; terminal chlamydospores present.

Hab. On cut surfaces of oak, elm, and other trees, also on *Solanum tuberosum*, on tulip bulbs, and in the soil.

6. *Fusarium udum* (Berk.) Wr. var. **Solani** n. var. (Figs. 1G and 5)

Conidia dorsiventral, usually somewhat broader toward the slightly rounded apex, apedicellate, typically 3–septate, 30.2 x 4.27 (25–34 x 4–4.5)μ, non– to two–septate very rare when mature, 4– and 5–septate rare, of from light vinaceous cinnamon to orange-cinnamon hues on agars rich in glucose; chlamydospores usually found only in old cultures, terminal and intercalary, in conidia, in the tips of sterigmata, and in mycelium, often of dense orange color, 0–septate, 6 x 5.5μ; aërial mycelium present only near margin of colony growth, very loose, short, hyaline; substratum colorless or approaching the color of the conidia.

Hab. On rotted tubers of *Solanum tuberosum*, together with *Ramularia Solani*, Long Island, New York.

Differs from *F. udum* (Berk.) Wr. in that the conidia are shorter and thicker, and somewhat broader toward the apex.

The following measurements were taken:

On slightly acidified hard potato agar, culture eight days old:

Conidia: 0– and 1–septate, only when young
3–septate, 100 per cent, 33 x 4.25 (28–39 x 3.5–4.7)μ

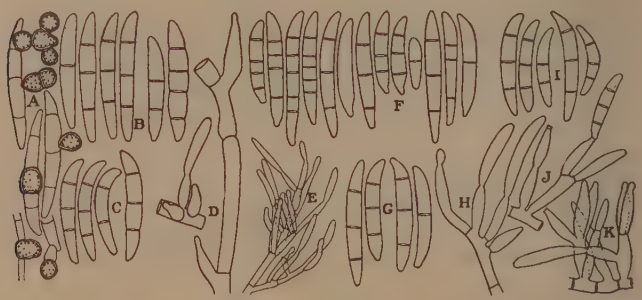


FIG. 5.—*Fusarium udum var. Solani.* A, *Different forms of chlamydospores from 85-days-old culture on hard potato agar with 5 per cent glucose;* B, *conidia from 9-days-old culture on hard lima-bean agar;* C, *conidia,* D, *conidiophores, from 49-days-old culture on rye straw;* E, *conidiophores (magnified 250 times) from 8-days-old culture on slightly acidified hard potato agar;* F, *conidia from 72-days-old culture on potato tuber plug;* G, *conidia,* H, *conidiophores, from 8-days-old culture on slightly acidified hard potato agar;* I, *conidia,* J, K, *conidiophores, from 74-days-old culture on red raspberry cane plug*

On red raspberry cane plug, culture seventy-four days old:

(1) From an advanced part of colony growth

Conidia: 1–septate, rare
2–septate, 10 per cent, 22 x 3.8 (19.5–24 x 3.3–4.1)μ
3–septate, 90 per cent, 25 x 4 (22–31 x 3.9–4.6)μ

(2) From an old part of colony growth

Conidia: 3–septate, 100 per cent, 28 x 4μ dominant type
4–septate, rare

On potato tuber plug, culture seventy-two days old:
Conidia: 0–septate, rare, young
1–septate, 5 per cent, mostly young
2–septate, 2 per cent, mostly young
3–septate, 86 per cent, 31 x 4.4 (23–40 x 3.9–4.7)μ
4–septate, 7 per cent, 32 x 4.4 (28–40 x 4.1–4.7)μ
5–septate, rare, 35 x 4.4 (30–40 x 4–4.6)μ

On hard lima-bean agar, culture four days old:
Conidia: 1–septate, 1 per cent, young
2–septate, 4 per cent, 31 x 4.4
3–septate, 95 per cent, 34 x 4.5 (25–40 x 4.1–4.9)μ
4–septate, rare, 40 x 5.1 (only a few measured)

Average of the above measurements:
Conidia: 0–septate, rare to none
1–septate, 1.5 per cent, (usually immature)
2–septate, 4 per cent
3–septate, 93 per cent, 30.2 x 4.27μ
4–septate, 1.5 per cent, 36 x 4.75μ
5–septate, rare to none

IV. SECTION GIBBOSUM Wr., Phytopath. 3:31, fig. 1, L and M

Conidia with from hyperbolic or parabolic to elliptic dorsal curve, conspicuously broader in the middle, with more or less long, narrow apex, prominently pedicellate, mostly 5–septate; intercalary chlamydospores always present; color of substratum and conidial mass typically from pale buff to cinnamon and sepia; mycelium from hyaline to brown.

7. *Fusarium gibbosum* Ap. et Wr. (Figs. 1Y and 6)

Appel, O., and Wollenweber, H. W., Arb. K. biol. Anst. Land- u. Forstw. 8:185–190, text fig. 10, C and D. 1910. Wollenweber, H. W., Phytopath. 3:32, fig. 1, M. 1913.

Conidia often with hyperbolic dorsal curve, conspicuously broader in the middle, with long, narrow apex, prominently pedicellate, typically 5-septate, 41.6 x 4.6 (40–46 x 4.4–4.7)μ, sometimes also 0– to 7–septate, in minute nonconverging sporodochia or spreading over mycelium singly, from hyaline to light pinkish cinnamon in color; chlamydospores inter-

calary, always present; aërial mycelium typically present, short, fine, medium loose; colony faintly zonate; substratum on potato agar rich in glucose, from pale flesh to cinnamon in color.

Hab. On stems and tubers of *Solanum tuberosum* in Germany, rare.

The organism was not isolated by the writer, but a culture of it was carefully examined on several different media with the following results in regard to spore septation and size:

On slightly acidified hard potato agar, culture twenty-four days old:

Conidia: 3–septate, 5 per cent
4–septate, 15 per cent, 32–4.1 μ
5–septate, 80 per cent, 43.2 x 4.6 (38–50 x 4.3–4.9) μ

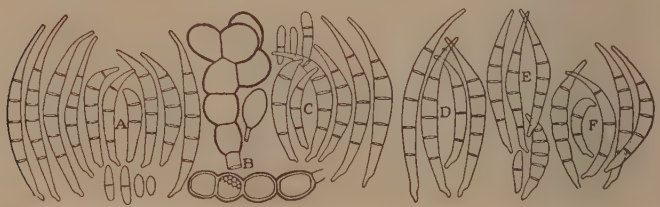


FIG. 6.—*Fusarium gibbosum.* A, *Pseudopionnotal conidia from 10-days-old culture on hard lima-bean agar;* B, *intercalary chlamydospores,* C, *conidia, from 71-days-old culture on red raspberry cane plug;* D, *pseudopionnotal conidia from 118-days-old culture on hard lima-bean agar with 2 per cent glucose;* E, *conidia from 42-days-old culture on potato stem plug;* F, *pseudopionnotal conidia from 24-days-old culture on slightly acidified hard potato agar*

On red raspberry cane plug, culture seventy-one days old:

Conidia: 3–septate, 5 per cent
4–septate, 5 per cent
5–septate, 90 per cent, 40 x 4.6 (33–46 x 4.2–5.2) μ
6–septate, rare

On hard lima-bean agar with 2 per cent glucose, culture one hundred and eighteen days old:

Conidia: 4–septate, 1 per cent
5–septate, 94 per cent, 37 x 4.6 (26–44 x 3.9–4.9) μ
6–septate, 3 per cent, 42 x 4.7 μ
7–septate, 2 per cent

On hard lima-bean agar, culture ten days old:

Conidia: 0–septate, 1.5 per cent, 7.5 x 3.2 μ
1–septate, 4 per cent, 10 x 3.2 (7–17 x 2.7–3.5) μ
2–septate, very rare
3–septate, 4 per cent, 27 x 4.1 (19–41 x 3.5–4.1) μ
4–septate, 3 per cent
5–septate, 86 per cent, 46 x 4.4 (35–58 x 4–4.8) μ
6–septate, 1.5 per cent, 52 x 4.5 (50–60 x 4.3–4.8) μ

Average of the above measurements:

Conidia: 0–septate, 0.5 per cent, 7.5 x 3.2 μ
1–septate, 1 per cent, 10 x 3.2 μ
2–septate, very rare
3–septate, 4 per cent, 27 x 4.1 μ
4–septate, 6 per cent, 27 x 4.1 μ
5–septate, 87 per cent, 41.6 x 4.6 μ
6– and 7–septate, 1.5 per cent, 47 x 4.6 μ

The averages of Appel and Wollenweber's (1910:189–190) measurements are as follows:

Conidia: 3–septate, 3 per cent, 25 x 4.5 μ
4–septate, 2 per cent, 29 x 4.5 μ
5–septate, 59 per cent, 42 x 4.4 μ
6–septate, 23 per cent, 49 x 4.6 μ
7–septate, 13 per cent, 49 x 4.7 μ

There is a notable difference between the data presented by the writer and those of Wollenweber only in the proportion of 6– and 7–septate conidia, the size of 5– and of 6– and 7–septate conidia being very much the same.

8. *Fusarium falcatum* Ap. et Wr. (Figs. 1x and 7)

Appel, O., and Wollenweber, H. W., Arb. K. biol. Anst. Land- u. Forstw. 8:175–185; Pl. II, figs. 100 to 110; Pl. III, fig. 9; text fig. 10, A. 1910.

Syn. *Fusarium vasinfectum* var. *Pisi* Schikorra, Arb. K. biol. Anst. Land- u. Forstw. 4:157, Pl. VII, 1906; not *F. vasinfectum* var. *Pisi* van Hall, Ber. deut. Bot. Gesell. 21:4, pl. 4, 1903. Wollenweber, Phytopath. 3:31, fig. 1, L, 1913.

Conidia often with parabolic dorsal curve, conspicuously broader in the middle, with long and narrow apex, prominently pedicellate, typically 5–septate, 49.1 x 4.6 (43–54.5 x 4.5–4.7)μ, often 3- to 7–septate, 0- to 2- and 8–septate very rare, in minute sporodochia more or less converging into pseudopionnotes, from buff-pink to cinnamon on hard potato agar rich in glucose; intercalary chlamydospores always present; aërial mycelium very poorly developed or not developed at all, leaving slimy layer exposed; substratum about the same color as the spores.

Hab. Often on *Pisum sativum*, seldom on underground part of stem of *Solanum tuberosum*, in Germany, and cause of fruit rot of *Solanum lycopersicum* in Germany and in the United States.

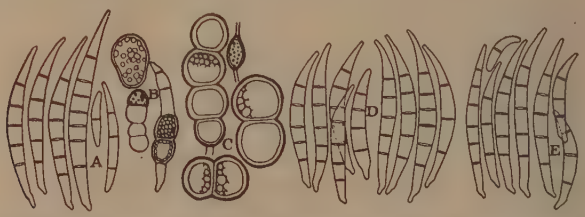


FIG. 7.—*Fusarium falcatum.* A, *Pseudopionnotal conidia,* B, *chlamydospores in mycelium and in spore, from 119-days-old culture on hard lima-bean agar with 2 per cent glucose;* C, *chlamydospores,* D, *pseudopionnotal conidia, from 71-days-old culture on red raspberry cane plug;* E, *pseudopionnotal conidia from 42-days-old culture on potato stem plug*

Differs from *F. gibbosum* mainly in having parabolic dorsal curve and typically exposed pseudopionnotes; also in considerably longer conidia.

The organism was not isolated by the writer, but the culture was obtained through the courtesy of Dr. Wollenweber. The writer's cultural observations in regard to septation and size of spores of this organism on various media are as follows:

On slightly acidified hard potato agar, culture twenty-four days old:

Conidia: 3–septate, 3 per cent, 28–42 x 3.5–4μ
4–septate, 9 per cent, 33–42 x 3.5–4μ } (only a few measured)
5–septate, 77 per cent, 50 x 4.5 (43–58 x 4–5.3)μ
6–septate, 10 per cent, 54 x 5 (50–60 x 4.8–5.3)μ
7–septate, 1 per cent, about 60–70 x 4.8–5.3μ

On red raspberry cane plug, culture seventy-one days old:
Conidia: 3–septate, 2 per cent
4–septate, 3 per cent
5–septate, 90 per cent, 43 x 4.6 (36–49 x 4–5.2)μ
6–septate, 5 per cent, 46 x 4.8 (43–53 x 4.3–5.2)μ

On hard lima-bean agar with 2 per cent glucose, culture one hundred and nineteen days old:
Conidia: 1–septate, 2.5 per cent, 15 x 2.7μ (only two measured)
3–septate, 3 per cent, 30 x 3.6 (10–44 x 3–4.7)μ
4–septate, 5 per cent
5–septate, 81 per cent, 49 x 4.7 (42–55 x 4.3–5.2)μ
6–septate, 6 per cent, 51 x 4.9 (45–56 x 4.6–5.2)μ
7–septate, 2.5 per cent, 52 x 5.2 (47–58 x 5.2)μ
8–septate, exceptionally rare, 58 x 5.4 (only one measured)

On hard lima-bean agar, culture eleven days old:
Conidia: 0–septate, rare
2–septate, 2 per cent
3–septate, 30 per cent, 30 x 3.6 (20–40 x 3–4.3)μ
4–septate, 5 per cent
5–septate, 62 per cent, 54.5 x 4.5 (43–65 x 3.5–5.2)μ
6–septate, 1 per cent, 64 x 4.8 (59–70 x 4.6–5.3)μ
7–septate, rare, same as 6–septate

Average of the above measurements:
Conidia: 0–septate, very rare
1–septate, 0.5 per cent
2–septate, 0.5 per cent, 15 x 2.7μ
3–septate, 9.5 per cent, 30 x 3.6μ
4–septate, 5.5 per cent
5–septate, 77.5 per cent, 49.1 x 4.56μ
6–septate, 5.5 per cent, 54 x 4.9μ
7–septate, 1 per cent, 58 x 5.1μ
8–septate, very rare, 58 x 5.4μ

Averages of Appel and Wollenweber's (1910:184) measurements are as follows:
Conidia: 5–septate, 46 x 4.7μ
6–septate, 49 x 4.4μ

The measurements of the writer show some deviation from these, but the deviation is small and can be explained entirely by the fact that the writer's measurements were taken from much younger cultures, which usually yield somewhat longer conidia than those produced in old cultures.

9. *Fusarium falcatum* Ap. et Wr. var. **fuscum** n. var. (Fig. 8; Pl. VII, fig. 8)

Conidia with from ellipsoidal to parabolic dorsal curve, conspicuously broader in the middle, prominently pedicellate, typically 5–septate,

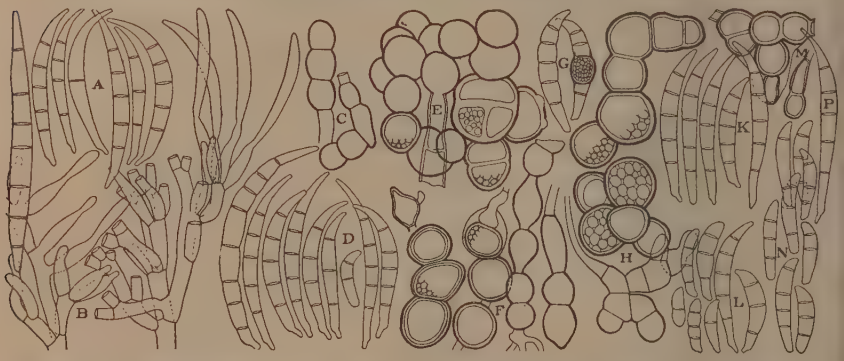


FIG. 8.— *Fusarium falcatum var. fuscum.* A, *Pseudopionnotal conidia,* B, *conidiophores, from 4-days-old culture on hard potato agar;* C, *intercalary chlamydospores,* D, *pseudopionnotal conidia, from 10-days-old culture on hard bean agar;* E, *cluster of intercalary chlamydospores from 99-days-old culture on potato tuber plug;* F, *intercalary chlamydospores in long chains,* G, *conidia with and without chlamydospores, from 176-days-old culture on corn agar;* H, *young and old chlamydospores,* K, *sporodochial,* L, *aërial, conidia, from 79-days-old culture on red raspberry cane plug;* M, *intercalary and terminal chlamydospores,* N, *aërial conidia, from 50-days-old culture on rye straw;* P, *typical conidium from a large sporodochium of 29-days-old culture on hard oat agar*

45 x 4.6 (40–51 x 4.4–4.7)μ, 3– and 4–septate ones also present, 6– and 7–septate rare, 8–septate very rare, typically in conspicuous plectenchymic or aplectenchymic sporodochia, from light buff and honey yellow to buckthorn and cacao brown, on potato agar rich in glucose; chlamydospores intercalary, always present, sometimes by their abundance and color making the entire medium and the aërial mycelium of a dark brown color; aërial mycelium always present, high, from fine to medium fine, more or less loose, hyaline at first, later becoming from tawny olive to brown; color of substratum on agars from hyaline to that of the spores.

Hab. On rotted tubers of *Solanum tuberosum*, New York State.

Differs from *F. falcatum* mainly by large sporodochia, more profuse chlamydospore production, well-developed aërial mycelium, and typical absence of pseudopionnotes.

The organism was isolated only once, from a potato tuber slightly rotted near the stem end, which was received from a potato grower in New York. The measurements of conidia on different media are as follows:

On slightly acidified hard potato agar, culture four days old:

Conidia: 0– and 1–septate, few, very young
3–septate, 4 per cent, 38 x 4.3 (35–42 x 4.1–4.7)μ
4–septate, 6 per cent, 41.6 x 4.4 (35–44 x 4.1–4.7)μ
5–septate, 88 per cent, 45.5 x 4.6 (40–49 x 4.1–4.8)μ
6– and 7–septate, 2 per cent, 50–80 x 5.5μ (only a few measured)
The largest 5–septate conidium observed measured 67 x 5.8μ

On red raspberry cane plug, culture seventy-nine days old:

Conidia: 3–septate, 1 per cent
4–septate, 4 per cent
5–septate, 95 per cent, 40 x 4.7 (31–48 x 4.3–5.2)μ

On hard lima-bean agar, culture ten days old:

Conidia: 3–septate, 3 per cent, 34 x 4.4 (19–40 x 3.1–4.7)μ
4–septate, 6 per cent
5–septate, 91 per cent, 45 x 4.4 (36–61 x 4–4.8)μ

On hard oat agar, culture twenty-nine days old, from a sporodochium about 3 millimeters in diameter:

Conidia: 3–septate, 2 per cent
4–septate, 5 per cent
5–septate, 93 per cent, 51 x 4.6 (45–53 x 4.1–4.9)μ

Average of the above measurements:

Conidia: 3–septate, 2.5 per cent, 36 x 4.3μ
4–septate, 5 per cent, 41.6 x 4.4μ
5–septate, 92 per cent, 45 x 4.6μ
6– and 7–septate, 0.5 per cent

10. *Fusarium caudatum* Wr. var. **Solani** n. var. (Figs. 1z and 9; Pl. IV, fig. 7; Pl. VI, fig. 3)

Conidia with from parabolic to ellipsoid dorsal curve, conspicuously broader at the middle, with very long, narrow, whiplike apex, prominently pedicellate, typically 5- to 7-septate; measuring on the average, 5-septate, 48 x 4.6 (40–55 x 4.3–4.7)μ, 7 septate, 64.7 x 4.6 (57–69 x 4.4–4.8)μ; rarely in pseudopionnotes, typically in small aplectenchymic sporodochia, tinted from cream-buff to cinnamon, clay, and Saccardo's amber in a

FIG. 9.— *Fusarium caudatum var. Solani.* A, *Pseudopionnotal conidia,* B, *conidiophores, from 9-days-old culture on slightly acidified hard potato agar;* C, *pseudopionnotal conidia from 38-days-old culture on potato stem plug;* D *and* E, *chlamydospores from 50-days-old culture on red raspberry cane plug (magnification 250 times);* F, *conidia from aërial sporodochium of 118-days-old culture on hard lima-bean agar with 2 per cent glucose;* G, *cluster of chlamydospores,* H, *aërial conidia, from 50-days-old culture on rye straw;* I, *sporodochial conidia in oozing drop of liquid from 9-days-old culture on hard lima-bean agar;* J, *aërial conidia,* K, *intercalary chlamydospores, from 69-days-old culture on red raspberry cane plug*

plate culture on a potato hard agar rich in glucose; chlamydospores intercalary, always present in greater or less abundance; aërial mycelium very well developed, high, uniform, medium dense, from hyaline when young to sepia in old cultures, mostly from brownish to dresden brown; substratum, on potato agar rich in glucose, from pinkish buff when young to ochraceous tawny and snuff brown shaded to sepia in very old cultures.

Hab. On superficial dry-rot spots on tubers of *Solanum tuberosum,* Atlanta, New York.

Differs from *F. caudatum* Wr. (see Wollenweber 1914:262–263, Pl. XVI, . M) mainly by broader conidia, which in the latter organism average ly from 3 to 4.5μ in diameter.

The organism was twice isolated, in 1912 and in 1913, from superficial y rot of potato tubers collected at Atlanta, New York. The measure- ents of conidia on different media are as follows:

On red raspberry cane plug, culture sixty-nine days old:
nidia: 3–septate, 10 per cent, 30 x 4 (26–35 x 3.5–4.5)μ
4–septate, 5 per cent, 34 x 4.4 (32–40 x 4–4.8)μ
5–septate, 85 per cent, 40 x 4.8 (33–55 x 4–5.4)μ

On slightly acidified hard potato agar, culture nine days old:
nidia: 3–septate, 1 per cent, about 38 x 4μ (only a few measured)
4–septate, 8 per cent, about 40 x 4.2μ (only a few measured)
5–septate, 43 per cent, 55 x 4.3 (38–69 x 3.5–5.9)μ
6–septate, 27 per cent, 65 x 4.4 (55–84 x 4.1–5.3)μ
7–septate, 21 per cent, 69 x 4.4 (60–85 x 4.1–5.9)μ
8–septate, very rare

On hard lima-bean agar with 2 per cent glucose, culture one hundred d eighteen days old:
nidia: 4–septate, 1 per cent
5–septate, 29 per cent, 46 x 4.7 (43–59 x 4.3–5.2)μ
6–septate, 32 per cent, 53 x 4.8 (48–60 x 4.3–5)μ
7–septate, 37 per cent, 57 x 4.8 (50–62 x 4.7–5)μ
8–septate, 1 per cent, 61 x 5μ (only one measured)

On hard lima-bean agar, culture nine days old:
nidia: 5–septate, 55 per cent, 52 x 4.5 (45–61 x 4–4.8)μ
6–septate, 35 per cent, 65 x 4.7 (55–71 x 4.3–4.8)μ
7–septate, 10 per cent, 68 x 4.7 (58–78 x 4.3–4.8)μ

Average of the above measurements:
nidia: 3–septate, 3 per cent, 34 x 4μ
4–septate, 3.5 per cent, 37 x 4μ
5–septate, 53 per cent, 48 x 4.6μ
6–septate, 23.5 per cent, 58 x 4.6μ
7–septate, 17 per cent, 64.7 x 4.6μ
8–septate, rare, 61 x 5μ (only one measured)

V. Section Roseum Wr. (emended), Phytopath. 3:32, fig. 1 N, 1913

Conidia broad ellipsoid, typically of an even diameter for a considerable part of their length, comparatively narrow (from 3.6 to 4.3μ in average diameter), always very gradually attenuate toward both ends, conidia of all fruiting forms of the same shape and type; true chlamydospores always absent; on agars rich in glucose, from honey yellow and morocco red to Eugenia red, sometimes nearly hyaline.

11. *Fusarium acuminatum* Ell. et Ev. emend. Wr.

Cf. Wollenweber, H. W., Journ. Agr. Research 2:269–270, Pl. xvi, fig. G. 1914. *Fusarium acuminatum* Ell. et Ev., Proc. Acad. Sci. Phila. 1895:441. Saccardo, Syll. Fung. 14:1125–1126. 1899. Wollenweber's diagnosis (page 269 of reference cited) is as follows:

"Conidia, scattered, in sporodochia or in pionnotes, orange in mass. Conidia average as follows: 5–septate, 40 to 70 by 3 to 4.5μ; 4–septate (less common), 30 to 60 by 3 to 4.5μ; 3–septate, 20 to 45 by 2.75 to 4.25μ. Conidia of 0–, 1–, 2–, 6–, and 7–septations are occasionally found. Subnormal small conidia may be mistaken for conidia of the section Discolor, but normal sporodochia develop on repeatedly whorl-like branched conidiophores, giving the characteristic conidia of the section Roseum. The conidia show in side view hyperbolic or parabolic curves, in contrast to *Fusarium metacroum* App. and Wollenw., the conidia of which are as a rule more nearly straight. Blue globose sclerotia, 50–70μ thick, occur and form a striking contrast to the carmine plectenchymatic thallus on starchy media, such as steamed potato tubers. Both blue and carmine are basic modifications of the fungus, while yellow (on rice) is the acid one, turning blue to purple violet with the addition of an alkali.

"Habitat. Occurs on partly decayed plants, especially on stems, roots, and tubers, also on fruits. Found on Solanum, Ipomoea, Fagus (beech nuts), and *Impatiens balsamina* in the United States of America."

Ellis and Everhart's description is incomplete, but Wollenweber says (on page 270 of reference cited) that he "found this fungus so widely distributed on potato stems in the New England States that he feels justified in identifying it as *Fusarium acuminatum*." The writer did not study this fungus.

12. *Fusarium metacroum* Ap. et Wr. (Fig. 10; Pl. VII. fig. 5)

Appel, O., and Wollenweber, H. W., Arb. K. biol. Anst. Land- u. Forstw. 8:132–141; Pl. I, figs. 111 to 118; Pl. III, fig. 8. 1910.

Conidia broad, ellipsoid, more or less pointed at apex, seldom prominently pedicellate, typically 5–septate, 53 x 4.1 (43–65 x 3.8–4.3)μ, often 3- or 4–septate, seldom 0- to 2–, rarely 6–, exceptionally up to 12–septate, in minute, more or less converging, sporodochia forming exposed pseudopionnotes, from corinthian red to clay color, typically from dragon's-

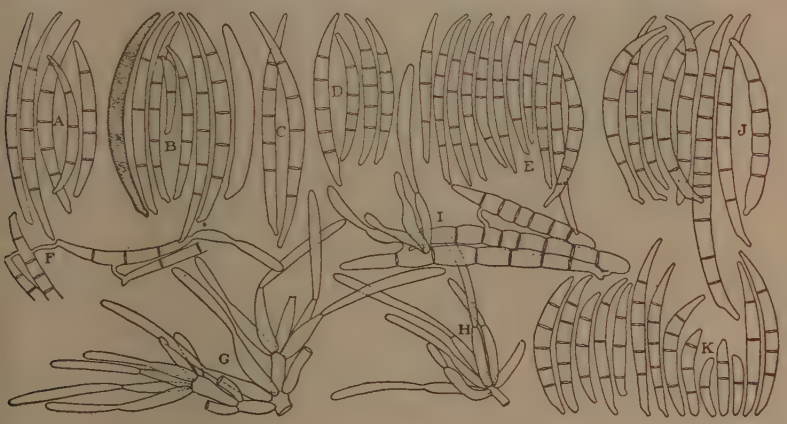


FIG. 10.—*Fusarium metacroum. Pseudopionnotal conidia:* A, *from 65-days-old culture on rye grain:* B, *from 10-days-old culture on hard lima-bean agar;* C, *from 8-days-old culture on hard lima-bean agar with 2 per cent glucose;* D, *from 113-days-old culture on potato stem plug;* E *and* F, *from 23-days-old culture on red raspberry cane plug;* I *and* J, *from 11-days-old culture on slightly acidified hard potato agar;* K, *from 66-days-old culture on rye grain.* G *and* H, *Conidiophores from 23-days-old culture on red raspberry cane plug*

blood red to brick red; chlamydospores absent; aërial mycelium typically absent; substratum from madder brown and brazil red to russet color; conidia often densely granulate with indistinct septation.

Hab. On grains of *Triticum vulgaris* in Germany and on rotted tubers of *Solanum tuberosum* in New York State.

The organism was isolated, together with *F. diversisporum*, from a rotted tuber from Long Island. The two fungi were growing together, and in the original culture the mixture appeared to be a pink Fusarium. The fungi were separated by dilution and remained very distinct from each

other. *F. metacroum* isolated by the writer is in all respects identical with the originally described organism.

The measurements of the conidia from the original culture when grown on various media are as follows:

On red raspberry cane plug, culture twenty-three days old:
Conidia: 3–septate, 42 per cent, 46 x 3.2 (35–56 x 2.6–4.1)μ
4–septate, 28 per cent, 50 x 3.5 (40–62 x 2.9–4.1)μ
5–septate, 30 per cent, 50 x 3.8 (45–63 x 3.3–4.3)μ

On hard lima-bean agar with 2 per cent glucose, culture eleven days old:
Conidia: 3–septate, 8 per cent
4–septate, 7 per cent
5–septate, 75 per cent, 54 x 4.1 (35–62 x 3.5–5.7)μ
6–septate and more, 10 per cent, the largest spore 12–septate, 91 x 5.3μ

On slightly acidified hard potato agar, culture eight days old:
Conidia: 3–septate, 15 per cent
4–septate, 15 per cent
5–septate, 70 per cent, 65 x 4.2 (55–73 x 3.8–4.8)μ

On potato tuber plug, culture ninety-eight days old:
Conidia: 1–septate, 5 per cent, 19 x 3 (14–21 x 2.7–3.5)μ
2–septate, few
3–septate, 10 per cent, 36 x 3.8 (28–43 x 3.5–4.2)μ
4–septate, 30 per cent, 46 x 3.9 (36–51 x 3.5–4.7)μ
5–septate, 55 per cent, 50 x 4 (42–63 x 3.5–4.4)μ

On potato stem plug, culture one hundred and thirteen days old:
Conidia: 3–septate, 25 per cent, 36 x 3.7 (33–39 x 3.4–3.9)μ
4–septate, 20 per cent, about 39 x 4μ (only a few measured)
5–septate, 55 per cent, 43 x 4 (38–47 x 3.5–4.2)μ, the longest 5–septate, 63 x 3.85μ

On whole steamed potato tuber, culture thirty-eight days old:
Conidia: 3–septate, 40 per cent, 42 x 3.9 (37–53 x 3.5–4.1)μ
4–septate, 35 per cent, 45 x 4.1μ
5–septate, 25 per cent, 54 x 4.3 (47–63 x 3.7–4.8)μ

On rye grain, culture sixty-five days old:

(1) From a slimy heap of conidia 1 millimeter in diameter

Conidia: 3–septate, 27 per cent, 43 x 3.8 (31–49 x 2.9–4.7)μ
4–septate, 11 per cent, 44 x 4.1 (40–63 x 2.6–4.8)μ
5–septate, 62 per cent, 54.5 x 4.1 (43–67 x 3–5.2)μ

(2) From a minute, semi-dry fleck of conidia, culture sixty-six days old

Conidia: 0–septate, 2 per cent
1–septate, 3 per cent, 20 x 3.5
2–septate, 3 per cent, 23 x 3.9 } (only a few measured)
3–septate, 65 per cent, 32 x 3.9 (22–47 x 3.5–4.4)μ
4–septate, 12 per cent, 43 x 4.1 (38–48 x 3.5–4.4)μ
5–septate, 15 per cent, 45 x 4.3 (38–48 x 3.5–4.7)μ, the largest 53 x 5.25μ

On hard lima-bean agar, culture ten days old:

Conidia: 3–septate, 6 per cent, 48 x 3.7μ (only three measured)
4–septate, 4 per cent
5–septate, 90 per cent, 61 x 3.9 (43–68 x 3.5–4.1)μ

Average of the above measurements:

Conidia: 0– to 2–septate, rare
3–septate, 26 per cent, 40.4 x 3.7μ
4–septate, 19 per cent
5–septate, 54 per cent, 53 x 4.1μ
6– and 7–septate, 1 per cent

The averages of Appel and Wollenweber's measurements are as follows:

Conidia: 3–septate, 9 per cent, 39 x 3.9μ
4–septate, 14 per cent, 43 x 4.2μ
5–septate, 76 per cent, 53 x 4.3μ
6–septate, 1 per cent, 63 x 4.6μ

13. *Fusarium metacroum* Ap. et Wr. var. **minus** n. var. (Fig. 11)

Conidial type as in *F. metacroum*, 5–septate conidia 54 x 3.6 (46–60 x 3.4–3.9)μ.

Hab. On stem of *Solanum tuberosum*, New York State.

Differs from *F. metacroum* by narrower conidia, often distinct plectenchymic substratum, and swellings in hyphæ very similar to true chlamydospores.

The organism was isolated only once, from a half-dead stem of potato plant at Atlanta, New York, from a pseudopionnotal spore mass. The measurements of the conidia produced by the organism on various media are as follows:

On red raspberry cane plug, culture thirty-one days old:
Conidia: 1–septate, 0.5 per cent, 20 x 2.5μ
2–septate, very few
3–septate, 46.5 per cent, 43 x 2.8 (23–53 x 2.3–3.5)μ
4–septate, 31 per cent, 48 x 3.2 (40–60 x 2.3–3.5)μ
5–septate, 22 per cent, 52 x 3.4 (42–60 x 2.9–4)μ
6–septate, rare, 61 x 3.4μ (only one measured)

FIG. 11.—*Fusarium metacroum var. minus.* A, *Conidia from 18-days-old culture on hard lima-bean agar;* B, *conidia from the original specimen, potato stem, August 7, 1912;* C, *chlamydospore-like structures of hyphæ from 26- and 176-days-old cultures on corn agar;* D, *conidiophore from the original specimen, potato stem, August 7, 1912;* E, *conidiophores from 31-days-old culture on red raspberry cane plug;* F, *conidia producing numerous conidiophores from 10-days-old culture on hard lima-bean agar;* G, *normal conidia from 10-days-old culture on hard lima-bean agar;* H, *conidiophores from 31-days-old culture on red raspberry cane plug;* I, *conidia from 31-days-old culture on red raspberry cane plug. All conidia are from pseudopionnotes*

On hard lima-bean agar with 2 per cent glucose, culture eight days old:
Conidia: 3–septate, 17 per cent
4–septate, 17 per cent
5–septate, 66 per cent, 60 x 3.6 (53–65 x 3–4.2)μ

On potato tuber agar, culture ninety-eight days old:
Conidia: 0–septate, 5 per cent
1–septate, 5 per cent
2–septate, rare
3–septate, 20 per cent, 34 x 3.5 (26–39 x 3–4)μ
4–septate, 30 per cent, 42 x 3.8 (36–48 x 3.5–4.1)μ
5–septate, 40 per cent, 46 x 3.9 (40–54 x 3.5–4.1)μ

On rye grain, culture sixty-five days old:
onidia: 3–septate, 20 per cent, 41 x 3.2 (36–46 x 2.9–4)μ
4–septate, 17 per cent, 48 x 3.3 (40–54 x 2.9–4)μ
5–septate, 63 per cent, 52 x 3.7 (40–60 x 3–4.1)μ

On hard lima-bean agar, culture ten days old:
onidia: 1–septate, very few
3–septate, 11 per cent, 50 x 3.3 (29–61 x 3–3.7)μ
4–septate, 4 per cent
5–septate, 85 per cent, 60 x 3.5 (45–67 x 3.1–4)μ

Average of the above measurements:
onidia: 0– to 2–septate, 2 per cent, 20 x 2.5μ
3–septate, 23 per cent, 42 x 3.2μ
4–septate, 20 per cent
5–septate, 55 per cent, 54 x 3.6μ
6–septate, very rare, 61 x 3.4μ

14. *Fusarium subulatum* Ap. et Wr. (Fig. 1w; Fig. 12, G to J; Pl. II, . 11; Pl. VII, fig. 4)

Appel, O., and Wollenweber, H. W., Arb. K. biol. Anst. Land- u. Forstw. 118–132, Pl. II, figs. 65 to 87. 1910. Wollenweber, H. W., Phytopath. 32, fig. 1N. 1913.

Conidia slightly elliptically curved, typically of nearly even diameter the greater part of their length, very gradually attenuate toward both ds, slightly pedicellate, typically 5 septate, 58 x 3.64 (48–65 x 3.4–3.85)μ, ually in numerous, sometimes converging sporodochia ($\frac{1}{4}$ to 1 millimeter diameter), produced near substratum and lower aërial mycelium, m pink-flesh to apricot-buff and from coral red to brick red in color, th darker shades in old moist cultures; chlamydospores absent; aërial ycelium typically present, at first hyaline, then testaceous color and ner hues of red; on various agars from vinaceous tawny and madder own to pomegranate purple and Eugenia red.

Hab. A cosmopolitan saprophyte, of very wide occurrence on dead bstrata, in soil and water, also parasitic on cereals and on tubers of *lanum tuberosum.*

The organism was twice isolated by the writer from rotted potato bers, and the strains were compared with a culture of the originally scribed organism obtained through the courtesy of Dr. Wollenweber

and proved to be identical. The writer's measurements of conidia the original strain are as follows:

On red raspberry cane plug, culture twenty-seven days old:
Conidia: 3–septate, 10 per cent, 55 x 2.9μ
4–septate, 20 per cent, 60.4 x 3 (54–76 x 2.6–3.5)μ
5–septate, 70 per cent, 65 x 3.4 (57–76 x 2.6–4.1)μ

On potato tuber plug, culture ninety-nine days old:
Conidia: 0– to 2–septate, none to very few
3–septate, 35 per cent, 33 x 3.7 (27–40 x 3–4)μ
4–septate, 20 per cent, 38 x 3.7 (32–42 x 3–4.1)μ
5–septate, 45 per cent, 48 x 3.85 (42–58 x 3.5–4.1)μ
6–septate, rare, 57 x 4μ (only one measured)

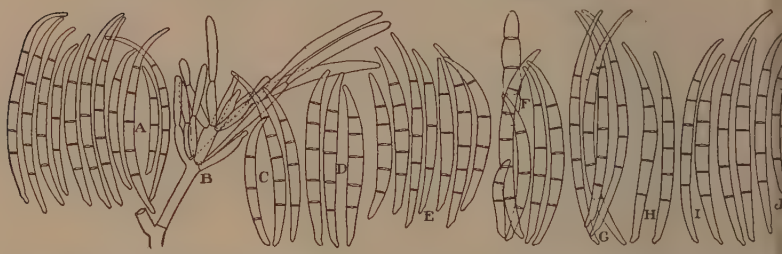


FIG. 12.— A-F, *Fusarium subulatum var. brevius:* A, *Conidia*, B, *conidiophore, from sm sporodochium of 31-days-old culture on red raspberry cane plug;* C, *sporodochial conidia fr 113-days-old culture on potato stem plug;* D, *pseudopionnotal conidia from 38-days-old cult on whole steamed potato tuber;* E, *sporodochial conidia from 65-days-old culture on rye stra* F, *aërial conidia from 10-days-old culture on hard lima-bean agar.*
G-J, *F. subulatum:* G, *Sporodochial conidia from 31-days-old culture on red raspberry ca plug;* H, *semi-dry conidia from sporodochium of 38-days-old culture on steamed potato tub* I, *sporodochial conidia from 113-days-old culture on potato stem plug;* J, *sporodochial coni from 65-days-old culture on rye grain*

On potato stem plug, culture one hundred and thirteen days old:
Conidia: 3–septate, 5 per cent, about 35 x 3μ (only a few measured)
4–septate, 4 per cent
5–septate, 91 per cent, 54 x 3.6 (47–65 x 3.2–3.9)μ

On steamed potato tuber, culture thirty-eight days old:
Conidia: 3–septate, 3 per cent, about 40 x 3.5μ
4–septate, 8 per cent, about 48 x 3.6μ
5–septate, 89 per cent, 55 x 3.7 (37–63 x 3.5–3.9)μ
6–septate, few, same measurement as 5–septate

On rye grain, culture sixty-five days old:

Conidia: 3–septate, 4 per cent, 52 x 3.4 (42–55 x 2.9–4)μ
4–septate, 15 per cent, 54 x 3.5 (42–67 x 2.9–4.1)μ
5–septate, 81 per cent, 64 x 3.7 (45–75 x 2.9–4.2)μ

On hard lima-bean agar, culture ten days old:

Conidia: 0–septate, rare
2–septate, very rare
3–septate, 11 per cent, 45 x 3.1 (33–60 x 3–3.5)μ
4–septate, 19 per cent
5–septate, 70 per cent, 60 x 3.6 (53–67 x 3.1–4)μ
9–septate, rare, 69 x 5.7μ (only one measured)

Average of the above measurements:

Conidia: 0–septate, none to rare
1– and 2–septate, none to rare
3–septate, 11 per cent, 43.3 x 3.3μ
4–septate, 15 per cent
5–septate, 74 per cent, 58 x 3.64μ
6– to 9–septate, none to rare

The averages of Appel and Wollenweber's measurements for the same organism are as follows:

Conidia: 1–septate, rare
3–septate, 4–septate } 28 per cent { 36.5 x 3.86μ, 51.5 x 3.5μ
5–septate, 62 per cent, 61 x 3.86μ
6–septate, 9 per cent, 69 x 4μ
7–septate, 1 per cent

This shows the 5–septate conidia to be in about the same proportion and of about the same size as found by the writer.

15. *Fusarium subulatum* Ap. et Wr. var. **brevius** n. var. (Fig. 12, A to F; Pl. II, fig. 12; Pl. VII, fig. 3)

Conidia and fruiting forms of the same type as those of *F. subulatum;* chlamydospores also absent; 5–septate conidia average 50 x 3.8 (41–58 x 3.1–4.2)μ in size.

Hab. On rotted tuber of *Solanum tuberosum*, Ithaca, New York.

Differs from *F. subulatum* Ap. et Wr. mainly in shorter conidia, absence of carmine color in substratum, and high, better-developed, aërial mycelium.[39]

The measurements of the conidia on various media are as follows:

On red raspberry cane plug, culture thirty-one days old:

Conidia: 3–septate, 35 per cent, 40 x 2.7 (29–49 x 2.3–3.3)μ
4–septate, 20 per cent, 51 x 3 (45–53 x 2.3–3.4)μ
5–septate, 45 per cent, 55 x 3.1 (48–60 x 2.9–3.8)μ

On potato tuber plug, culture ninety-nine days old (in general, spores more or less deteriorated):

Conidia: 1–septate, 1 per cent
3–septate, 33 per cent, 30 x 3.6 (21–42 x 3–4)μ
4–septate, 20 per cent, 36 x 3.9 (33–42 x 3.5–4.1)μ
5–septate, 46 per cent, 41 x 4 (35–48 x 3.5–4.1)μ
6–septate, rare, 43 x 4.1μ (only one measured)

On potato stem plug, culture one hundred and thirteen days old:

Conidia: 3–septate, 67 per cent, 34 x 3 (28–49 x 2.9–3.6)μ
4–septate, 20 per cent, 42 x 3.3 (37–48 x 3–3.8)μ
5–septate, 13 per cent, 44.6 x 3.4 (38–47 x 3–3.8)μ

On whole steamed potato tuber, culture thirty-eight days old:

Conidia: 3–septate, 25 per cent, 37 x 3.8 (31–42 x 3.5 4)μ
4–septate, 35 per cent, 43 x 4 (36–49 x 3.5–9.2)μ
5–septate, 40 per cent, 47 x 4.1 (40–56 x 3.5–4.4)μ
6–septate, few, 52 x 4.4 (only a few measured)

On rye grain, culture sixty-five days old:

Conidia: 3–septate, 16 per cent, 42 x 4 (36–49 x 3.5–4.3)μ
4–septate, 17 per cent, 45 x 4.1 (36–54 x 3.5–4.3)μ
5–septate, 67 per cent, 51 x 4.2 (43–58 x 3.7–4.7)μ

On hard lima-bean agar, culture ten days old:

Conidia: 0–septate, very rare
1–septate, very rare
2–septate, very rare
3–septate, 24 per cent, 41 x 3.3 (36–48 x 3–3.5)μ
4–septate, 20 per cent
5–septate, 56 per cent, 52 x 3.9 (42–59 x 3.2–4.1)μ

[39] This grows straight up and out from the point of inoculation in a plate culture on potato agar in the first week of its growth, while the aërial mycelium in *F. subulatum* is always of a more or less loose, feltlike character, uniformly medium short over the surface of the colony.

On medium potato agar, culture ten days old:

Conidia: 3–septate, 9 per cent, about 45 x 3.3 (only two measured)
4–septate, 3 per cent
5–septate, 88 per cent, 58 x 3.5 (47–64 x 3.1–4)μ

Average of the above measurements:

Conidia: 0– to 2–septate, absent or more or less rare
3–septate, 30 per cent, 38.4 x 3.4μ
4–septate, 19 per cent
5–septate, 51 per cent, 49.8 x 3.76μ
6–septate, absent to 1 per cent, 47.5 x 4.25μ

16. **Fusarium effusum** n. sp. (Fig. 13; Pl. VII, fig. 6)

Conidia gradually pointed toward apex, distinctly but not prominently pedicellate, typically 5–septate, 50 x 4.3 (44.5–57 x 3.9–4.5)μ, often 3– to 7–, seldom 1– to 2–septate; single or in indistinct pseudopionnotes and in large (on oats, wheat, and the like, about $\frac{1}{2}$ centimeter in diameter) plectenchymic sporodochia; shape of conidia of nearly the same type, in all stages and in mass, of salmon color and its tints; aërial mycelium typically well developed, though on an agar may be resupinate, uniform, without any differentiated tufts or strands, from white to cream and tints of salmon color; substratum, on glucose agar, from chamois to morocco red, and on glucose-free agar, from colorless to Eugenia red; typical spore germination by straight, unbranched tubes (Fig. 13 J); mycelium in young colony (Fig. 13 H) typically composed of nearly straight, sparse in number, and more or less regular, branches.

Hab. On dry tubers of *Solanum tuberosum*, Minnesota.

Latin description.—Conidiis gradatim in apicem acutis, distincte sed non insignite pedicellatis, typice 5–septatis, 50 x 4.3 (44.5–57 x 3.9–4.5)μ, saepe 3–7–, raro 1–2–septatis; continuis vel in indistinctis pseudopionnotibus atque in magnis (in avena, tritico, etc., circa $\frac{1}{2}$ cm. diam.) plectenchymicis sporodochiis; conidiis prope eodem in omnibus gradibus typo, in totum "salmon-color" (R); aerio mycelio typice plene maturo, sed in agare interdum resupinato, uniformi, sine ullis discretis cristis aut fibris, ex albo "cream color" (R) "salmon color" (R) vel simili colore; substrato in agare glucoso e "chamois" (R) "morocco red" (R), in agare non glucoso ex hyalino "Eugenia red" (R); sporis per rectos et non ramosos cylindros typice germinatis (Fig. 13 J); mycelio in colonia juveni ex prope rectis, sparsis, plus minusve regularibus ramis composito.

Hab. In tuberibus aridis Solani tuberosi, Minnesota, Amer. bor.

The fungus was isolated in association with *F. Solani* from an old rotted potato tuber from Minnesota. Measurements of conidia from cultures on different media are as follows:

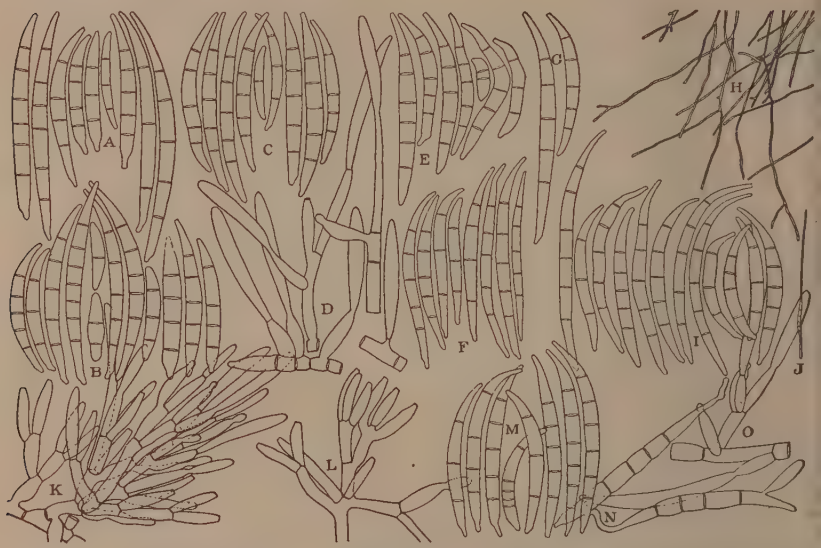


FIG. 13.—*Fusarium effusum.* A, *Pseudopionnotal conidia from 7-days-old culture on hard lima-bean agar with 2 per cent glucose;* B, *pseudopionnotal conidia from 13-days-old culture on hard lima-bean agar (rare forms of conidia shown at the center);* C, *pseudopionnotal conidia,* D, *conidiophores, from 9-days-old culture on medium potato agar;* E, *sporodochial conidia from 24-days-old culture on potato tuber plug;* F, *sporodochial conidia from 76-days-old culture on red raspberry cane plug;* G, *typical sporodochial conidia from 107-days-old culture on potato stem plug;* H, *character of colony growth (magnification 80 times),* I, *sporodochial conidia, from 34-days-old culture on rye grain;* J, *character of spore germination from potato-decoction hanging drop in van Tieghem cell (magnification 80 times);* K, L, *conidiophores,* M, *normal conidia,* N, *anastomosed conidia,* O, *conidiophores, from 36-days-old culture on corn meal*

On slightly acidified hard potato agar, culture ten days old; conidia from pseudopionnotes:

Conidia: 2–septate, rare
3–septate, 50 per cent, 34 x 4.1 (28–47 x 3–4.7)μ
4–septate, 10 per cent, 45 x 4.2μ
5–septate, 40 per cent, 50 x 4.5 (42–65 x 3.5–5.3)μ

On red raspberry cane plug, culture seventy-six days old; conidia from a sporodochium:

Conidia: 3–septate, 35 per cent, 42 x 3.3 (32–48 x 2.7–4)μ
4–septate, 15 per cent, 47 x 3.6 (42–53 x 3.2–4.3)μ
5–septate, 50 per cent, 49 x 3.9 (38–58 x 3.2–4.4)μ
6–septate, very rare

On hard lima-bean agar, 2 per cent glucose, culture seven days old; conidia from mycelium:

Conidia: 1–septate, 1 per cent
2–septate, 5 per cent
3–septate, 19 per cent, 39 x 4.2 (28–50 x 3.9–4.8)μ
4–septate, 10 per cent
5–septate, 60 per cent, 57 x 4.3 (52–72 x 4–5.3)μ
6–septate, 5 per cent, 62 x 4.7 (49–72 x 4.3–5.3)μ
7–septate, rare, 72 x 4.3μ (only one measured)
8–septate, exceptional, 87.5 x 5.8μ (only one measured)

On potato tuber plug, culture twenty-four days old; conidia from a sporodochium:

Conidia: 0–septate
1–septate, 2 per cent
2–septate, 1 per cent
3–septate, 12 per cent, 32 x 4.3 (28–36 x 3.9–4.4)μ
4–septate, 21 per cent, 34 x 4.5 (29–41 x 4.1–4.7)μ
5–septate, 61 per cent, 44.5 x 4.5 (35–51 x 4.1–4.8)μ
6– and 7–septate, 3 per cent, 53 x 4.7 (49–54 x 4.3–5.2)μ

On potato stem plug, culture one hundred and seven days old; conidia from a sporodochial mass (spores mostly with deteriorated ends):

Conidia: 3–septate, 5 per cent
4–septate, 15 per cent
5–septate, 80 per cent, 49 x 4 (35–63 x 3.5–4.7)μ

On hard lima-bean agar, culture ten days old; conidia from aërial mycelium:

Conidia: 1–septate, rare, 21 x 3.1μ (only one measured)
3–septate, 11 per cent, 36.2 x 4 (28–42 x 3.1–4.8)μ

4–septate, 4 per cent
5–septate, 81 per cent, 50.5 x 4.5 (38–60 x 3.9–4.8)μ
6–septate, 4 per cent, 56 x 4.7 (48–64 x 4.4–5.2)μ
7–septate, rare, 62 x 5.2μ (only one measured)

On the same medium as above, culture sixteen days old; conidia from aërial mycelium and indistinct pseudopionnotes:

Conidia: 1–septate, 1 per cent, 18 x 3.5μ (only a few measured)
2–septate, 1 per cent, 24 x 4μ (only a few measured)
3–septate, 12 per cent, 33 x 4 (21–44 x 2.9–4.8)μ
4–septate, 6 per cent
5–septate, 71 per cent, 50 x 4.3 (38–62 x 3.5–4.7)μ
6–septate, 7 per cent, 60 x 4.7 (55–64 x 4.5–4.8)μ
7–septate, 2 per cent, 62 x 4.7 (59–65 x 4.4–4.8)μ

Average of the above measurements:

Conidia: 1–septate, less than 1 per cent, 18 x 3.5μ
2–septate, 2 per cent, 24 x 4.0μ
3–septate, 20 per cent, 36 x 4.0μ
4–septate, 12 per cent
5–septate, 63 per cent, 50 x 4.3μ
6– and 7–septate, 3 per cent, 68 x 4.8μ

F. effusum, especially in its sporodochial stage, much resembles the following other species: *F. subulatum*, *F. lucidum*, *F. biforme*, *F. diversisporum*. From *F. subulatum* it can be at once distinguished by the diameter of the conidia and by the larger size of sporodochia.[40] From *F. lucidum* it differs primarily by the common presence of 6– and 7–septate conidia, which are absent in *F. lucidum*, and by denser red substratum than that of the latter species. From *F. biforme* it differs mainly by absence of the long, 9– or more septate, conidia in pseudopionnotes, and also by absence of arthrosporial conidial form, the pluriseptate conidia and arthrosporial conidia on aërial mycelium being more or less common in *F. biforme*. From *F. diversisporum* it differs by absence of arthrosporial conidia, which are typically produced on aërial mycelium of *F. diversisporum*.

[40] Sporodochia of *F. subulatum* as a rule are small, but on whole steamed potato tubers they may be as large as those of *F. effusum*.

17. Fusarium truncatum n. sp. (Figs. 1, C_1 to E_1, and 14; Pl. VII, fig. 1)

Conidia typically sickle-shaped, gradually pointed toward the apex, slightly broader at or just above the middle, distinctly pedicellate, 3– to 5–septate; 3–septate averaging 35 x 3.7 (31.5–42 x 3.4–3.9)μ, 5–septate averaging 45 x 3.9 (43–48 x 3.4–4.2)μ; from cinnamon and terra cotta to carmine-pomegranate purple in color; conidiophores from loose to dense, bushlike, single or in from small to large (up to $\frac{1}{2}$ centimeter in diameter) sporodochia; aërial mycelium always well developed, mostly composed of fine but macroscopically distinct threads, from white to slightly carmine near substratum; color of substratum, on hard potato agar rich in glucose,

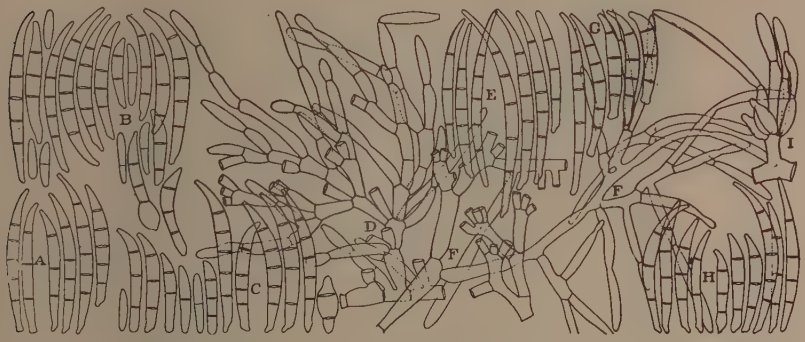


FIG. 14.— *Fusarium truncatum.* A, *Sporodochial conidia from 60-days-old culture on red raspberry cane plug;* B, *aërial conidia from 13-days-old culture on hard potato agar;* C, *aërial conidia (some with distinctly truncate basal cell) from 14-days-old culture on medium potato agar;* D, *conidiophore from 13-days-old culture on hard potato agar;* E, *sporodochial conidia from 14-days-old culture on medium potato agar;* F, *conidiophores from 47-days-old culture on potato tuber plug;* G, *sporodochial conidia from 37-days-old culture on hard oat agar;* H, *conidia from aërial mycelium from 47-days-old culture on potato tuber plug;* I, *conidiophore from 4-days-old colony in petri dish on hard potato agar with 10 per cent glucose*

varies from pale cinnamon and diffuse salmon hues to corinthian and brick red, more or less distinctly zonate.

Hab. On rotted tubers of *Solanum tuberosum*, New York State.

Latin description.—Conidiis typice falciformibus, gradatim in apicem acutis, paulo latioribus medio vel subinde supra medium, distincte pedicellatis 3–5–septatis; 3–septatis plerumque 35 x 3.7 (31.5–42 x 3.4–3.9)μ, 5–septatis plerumque 45 x 3.9 (43–48 x 3.4–4.2)μ; e "cinnamon" (R) et "terra cotta" (R) "carmine" (R) et "pomegranate purple" (R); co-

nidiophoris laxis demum dense, fruticosis, continuis vel in parvis magnisve (usque ad ½ cm. diam.) sporodochiis; acrio mycelio semper plene maturo, ex hyphis subtilibus sed macroscopice distinctis composito, ex albo paulum "carmine" (R) prope substratum; substrato in duro agare glucoso Solani tuberosi e pallide "cinnamon" (R) et "salmon color" (R) diffuse "corinthian" et "brick red" (R), plus minusve distincte zonato.

Hab. In tuberibus putridis Solani tuberosi, New York, Amer. bor.

Measurements of conidia from cultures on different media are as follows:

On slightly acidified hard potato agar, culture thirteen days old; conidia from aërial mycelium:

Conidia: 0–septate, 7 per cent
1–septate, 54 per cent
2–septate, 6 per cent
3–septate, 22 per cent, 31.5 x 3.75 (21–45 x 3.1–4.1)μ
4–septate, 4 per cent, 40 x 4.1 (32–49 x 3.5–4.7)μ
5–septate, 7 per cent, 43 x 4.1 (33–53 x 3.9–4.7)μ
6–septate, rare, 45 x 4.5μ (only two measured)

On potato tuber plugs, culture forty-six days old; conidia from a sporodochium 2 millimeters in diameter:

Conidia: 3–septate, 63 per cent, 37 x 3.4 (27–49 x 3–3.6)μ
4–septate, 22 per cent, 41 x 3.7 (40–45 x 3.5–4)μ
5–septate, 15 per cent, 43 x 3.7 (40–45 x 3.5–4.1)μ

On red raspberry cane plug, culture sixty days old; conidia from a sporodochium about 2 millimeters in diameter:

Conidia: 3–septate, 29 per cent, 37 x 3.9 (28–41 x 3.5–4.2)μ
4–septate, 31 per cent, 40 x 3.9 (35–43 x 3.5–4.2)μ
5–septate, 40 per cent, 44 x 4 (36–46 x 3.5–4.5)μ

On potato stem plug, culture eighty-three days old; conidia from a sporodochium about 1½ millimeters in diameter (many of the conidia much deteriorated):

Conidia: 3–septate, 20 per cent
4–septate, 16 per cent
5–septate, 64 per cent, 48 x 3.4 (44–51 x 3.1–3.7)μ

On soft potato agar, plate culture fourteen days old; conidia from thick pseudopionnotal mass near the inoculation point:

Conidia: 3–septate, 20 per cent, 42 x 3.4 (35–51 x 3–3.9)μ
4–septate, 13 per cent
5–septate, 67 per cent, 50 x 3.6 (43–65 x 3.1–3.9)μ

On same medium as above, plate culture also; conidia from a small sporodochium on aërial mycelium:

Conidia: 0–septate, rare
1–septate, 3 per cent, 16 x 3.1μ (only one measured)
2–septate, 2 per cent, 21 x 3.5μ (only one measured)
3–septate, 29 per cent, 33 x 3.8 (22 41 x 3.3–4.2)μ
4–septate, 19 per cent
5–septate, 47 per cent, 45 x 4.2 (36–64 x 4–4.4)μ

Average of the above measurements:

Conidia: 0–septate, about 1 per cent
1–septate, about 9 per cent
2–septate, about 1 per cent
3–septate, about 31 per cent, 34.8 x 3.7μ
4–septate, about 18 per cent
5–septate, about 40 per cent, 45 x 3.9μ
6–septate, very exceptional, 45 x 4.5μ (only two measured)

Conidia of *F. truncatum* often have a peculiar flat base, and this species can be separated from all the other Fusaria of potatoes by its typically (though not always) pomegranate purple to carmine conidial masses.

18. **Fusarium lucidum** n. sp. (Figs. 1v and 15; Pl. II, figs. 9 and 10; Pl. IV, fig. 12; Pl. VI, fig. 12)

Conidia typically ellipsoid, very gradually attenuate toward both ends, distinctly but not prominently pedicellate, 5–septate, 54 x 4.05 (43–63 x 3.7–4.7)μ, salmon, often of very bright hues, but paler or denser in from small to large (up to $\frac{1}{2}$ centimeter in diameter) sporodochia; no chlamydospores; conidiophores typically more or less compound, bushlike; mycelium from white to pale cinnamon and pomegranate near substratum; when first isolated the fungus has a substratum, on potato agar without glucose from pale pink to tints of pomegranate, and on the same medium with glucose from clay to buckthorn brown.

Hab. On rotted tubers of *Solanum tuberosum*, New York State.

Differs from *F. effusum* mainly by absence or very rare occurrence of 6– and 7–septate conidia.

Latin description.—Conidiis typice ellipsoidalibus, maxime in utrosque terminos gradatim attenuatis, distincte sed non insignite pedicellatis, 5–septatis, 54 x 4.05 (43–63 x 3.7–4.7)μ, "salmon-color" (R) magnis, in parvis (usque ad $\frac{1}{2}$ cm. diam.) sporodochiis; nullis chlamydosporis; conidiophoris typice plus minusve compositis, fruticosis; mycelio ex albo "pale cinnamon" (R) vel "pomegranate" (R) prope substratum; primum

FIG. 15.—*Fusarium lucidum.* A, *Sporodochial conidia,* B, *conidiophores, from 47-days-old culture on wheat kernels;* C, *pseudopionnotal conidia from 11-days-old culture on slightly acidified hard potato agar;* D, *sporodochial,* E, *aërial, conidia from 75-days-old red raspberry cane plug;* F, *pseudopionnotal conidia from 36-days-old culture on hard oat agar;* G, *sporodochial conidia,* H, *conidiophore, from 20-days-old culture on hard lima-bean agar with 2 per cent glucose;* I, *pseudopionnotal conidia from 7-days-old culture on hard lima-bean agar with 2 per cent glucose;* J, *sporodochial conidia from 65-days-old culture on potato stem plug;* K, *sporodochial conidia from 24-days-old culture on potato tuber plug;* L, *sporodochial conidia from 82-days-old culture on potato tuber plug (the two at the left abnormal)*

substrato, in agare Solani tuberosi non glucoso, e pallide rubello "pomegranate" (R) vel simili colore, in eodem agare glucoso, ex argillaceo "buckthorn-brown" (R).

Hab. In tuberibus putridis Solani tuberosi, New York, Amer. bor.

Measurements of conidia from cultures on different media are as follows:

On hard potato agar, slightly acidified, culture eleven days old; conidia from pseudopionnotes:

Conidia: 0–septate, rare
1–septate, 11 per cent, 17 x 3.1 (12–22 x 2.9–3.5)μ
2–septate, 7 per cent, 28 x 3.8 (20–32 x 2.9–4.3)μ
3–septate, 68 per cent, 43.7 x 3.8 (33–67 x 3–4.4)μ
4–septate, 4 per cent, 55 x 4.2 (47–65 x 4–4.4)μ
5–septate, 10 per cent, 63 x 4.4 (57–72 x 4–4.8)μ

On red raspberry cane plug, culture seventy-five days old; conidia from aërial mycelium:

Conidia: 0–septate, rare
1–septate, 1 per cent
3–septate, 5 per cent, 43 x 3.8 (25–48 x 3.5–4.4)μ
4–septate, 14 per cent, 45 x 3.8 (38–54 x 3–4.6)μ
5–septate, 80 per cent, 51 x 4.2 (42–60 x 3.5–4.7)μ
6–septate, rare

On potato tuber plugs, culture ninety-two days old; conidia from a mass of minute sporodochia:

Conidia: 0–septate, rare
1–septate, 3 per cent
2–septate, 2 per cent
3–septate, 25 per cent, 31 x 3.8 (24–36 x 3–4.1)μ
4–septate, 17 per cent
5–septate, 53 per cent, 46 x 3.9 (36–58 x 3.5–4.7)μ
6–septate, rare, 55–60 x 3.8–4.7μ (only a few measured)

On hard lima-bean agar with 2 per cent glucose, culture seven days old; conidia from aërial mycelium:

Conidia: 0–septate, 40 per cent
1–septate, 35 per cent
2–septate, 5 per cent
3–septate, 14 per cent, 41 x 4.2 (33–44 x 3.5–4.8)μ
4–septate, 5 per cent, 48 x 4.6 (42–53 x 4–5.3)μ
5–septate, 1 per cent, 56 x 4.7 (53–58 x 4.3–4.9)μ (only five spores measured, the largest 60 x 5.7μ)

On the same medium as above, culture twenty days old; conidia from a small sporodochium:

Conidia: 3–septate, 1 per cent
4–septate, 12 per cent, 44 x 4 (40–57 x 3.5–4.4)μ
5–septate, 87 per cent, 54 x 3.9 (40–68 x 3.5–4.2)μ

On potato tuber plug, culture twenty-four days old; conidia from aërial mycelium:

Conidia: 3–septate, 10 per cent, 46 x 3.4μ (only a few measured)
4–septate, 30 per cent, 47 x 3.5 (44–50 x 3–3.8)μ
5–septate, 60 per cent, 51 x 3.7 (48–57 x 3.4–4.2)μ
6–septate, rare, 60 x 4.2μ (only one measured)

On potato stem plug, culture one hundred and seven days old; conidia from a sporodochial mass (much deterioated):

Conidia: 3–septate, 15 per cent
4–septate, 5 per cent
5–septate, 80 per cent, 56 x 3.8 (50–63 x 3.5–4.2)μ

On steamed whole potato tuber, culture forty-nine days old; conidia from a white, semi-dry, sporodochial mass:

Conidia: 3–septate, 50 per cent, 36 x 3.9 (24–43 x 3.5–4.1)μ
4–septate, 35 per cent
5–septate, 15 per cent, 43 x 4.1 (39–46 x 3.9–4.4)μ

On same medium as above; conidia from a red (old?) sporodochial mass, nearly converging into semi-pionnotal layer:

Conidia: 0–septate, very rare
3–septate, 8 per cent, 46 x 3.7 (24–50 x 3–4)μ
4–septate, 12 per cent, 48 x 3.8 (41–52 x 3.5–4.1)μ
5–septate, 80 per cent, 54 x 4 (43–62 x 3.5–4.3)μ
6–septate, very rare, about 57 x 4.2μ (only a few measured)

On medium soft potato agar, culture fourteen days old; conidia from pseudopionnotes:

Conidia: 3–septate, 28 per cent, 42 x 3.6μ (only four measured)
4–septate, 10 per cent
5–septate, 62 per cent, 58 x 4 (43–65 x 3.5–4.7)μ

On hard lima-bean agar, culture fourteen days old; conidia from a sheet of small sporodochial masses spread over the substratum:

Conidia: 3–septate, 3 per cent, 41 x 3.2μ (only three measured)
4–septate, 1 per cent
5–septate, 96 per cent, 60 x 3.8 (52–70 x 3.5–5)μ

On wheat grain culture fourteen days old; conidia from small, semi-dry sporodochia:

Conidia: 1–septate, rare
3–septate, 14 per cent
4–septate, 26 per cent
5–septate, 60 per cent, 56 x 3.7 (49–64 x 3.3–4.1)μ

Average of the above measurements:

Conidia: 0–septate, about 3 per cent
1–septate, about 4 per cent, 17 x 3.1μ
2–septate, about 1 per cent
3–septate, about 20 per cent, 41 x 3.7μ
4–septate, about 14 per cent
5–septate, about 58 per cent, 54 x 4.05μ
6–septate, very rare, 58 x 4.2μ

VI. SECTION ARTHROSPORIELLA n. sec.

Microconidia short and broad, spindle-shaped, 0– to 3–septate[41]; sporodochial macroconidia when present sickle-shaped, mostly 5–septate, of Roseum type; pseudopionnotal microconidia mostly 5– and 5– to 7–, often to 9– and more, septate, from slightly curved to straight and anguiform; true chlamydospores absent; aërial mycelium from white to pale buff and different hues of red and pink; color of substratum from clay to different hues of red.

The section is a connecting link between sections Roseum and Sporotrichiella (through *F. arthrosporioides*).

19. **Fusarium diversisporum** n. sp. (Fig. 16; Pl. VII, fig. 12)

Conidia varying from arthrosporial (short, spindle-shaped, and having an average measurement when 3–septate and on aërial mycelium of 28 x

[41] These conidia, though often septate, represent an abbreviated type and thus can be termed microconidia. These microconidia are often referred to as arthrosporial because of their resemblance to the conidia of the genus Arthrosporium.

4.3μ) to sickle-shaped, 5–septate type dominant, in sporodochia and pseudopionnotes, measuring 48.5 x 3.63 (41–61 x 2.9–4.4)μ; in pseudopionnotes, 6– to 9–septate conidia are common, 60–100 x 4.7–5.2μ, from slightly curved to straight and anguiform, apically pointed, distinctly but not prominently pedicellate, in mass typically of light pink-cinnamon color; chlamydospores absent; sporodochia when present often of a large size (up to 3.7 centimeters in diameter); aërial mycelium typically well developed, of uniformly medium fineness, white; substratum, on potato

FIG. 16.—*Fusarium diversisporum.* A, *Pseudopionnotal conidia from 26-days-old culture on hard oat agar;* B, *sporodochial conidia,* C, *arthrosporial conidia,* D, *aërial conidiophores producing arthrosporial conidia, from 76-days-old culture on red raspberry cane plug;* E, *pseudopionnotal conidia from 8-days-old culture on hard lima-bean agar with 2 per cent glucose;* F, *typical sporodochial conidia from 113-days-old culture on potato stem plug;* G, *sickle-shaped, normal conidia,* H, *arthrosporial, more or less abnormal, conidia, from aërial mycelium of 45-days-old culture on whole steamed potato tuber;* I, *pseudopionnotal conidia,* J, *mycelial conidiophores and conidiophores produced directly on spores,* K, *conidia, from 10-days-old culture on medium potato agar;* L, *typical sporodochial conidia from 46-days-old culture on whole steamed potato tuber;* M, *chlamydospore-like structures in old conidia from 173-days-old culture on corn agar;* N, *sporodochial conidia from 42-days-old culture on rye straw;* O, *sporodochial conidia from 116-days-old culture on rye straw;* P, *sporodochial conidia from 24-days-old culture on potato tuber plug;* Q, *conidiophore from 24-days-old culture on potato tuber plug*

agar rich in glucose, ranging from onion-skin pink and clay color when young to Saccardo's amber in old cultures.

Hab. On rotted tubers of *Solanum tuberosum,* New York State, in close association with *F. metacroum.*

Latin description.—Conidiis ex arthrosporialibus (brevibus, falciformibus, atque, si 3–septata et in aerio mycelio, plerumque 28 x 4.3μ), falciformibus plerumque 5–septatis, 48.5 x 3.63 (41–61 x 2.9–4.4)μ in sporodochiis pseudopionnotibusque; in pseudopionnotibus, conidiis 6–9–septatis frequentibus, 60–100 x 4.7–5.2μ, parum curvatis rectis, demum anguiformibus, apice acutis, distincte sed non insignite pedicellatis, in totum typice pallide "pinkish cinnamon" (R); nullis chlamydosporis; sporodochiis, si exstant, saepe magnis (usque ad 3.7 cm. diam.); aerio mycelio typice plene maturo, uniformi mediocri subtilitate, albo; substrato—in Solani tuberosi agare perglucoso—in culturis juvenibus, "onion-skin pink" (R) vel "clay-color" (R), in culturis maturis "Saccardo's amber" (R).

Hab. In tuberibus putridis Solani tuberosi una cum F. metacroo, New York, Amer. bor.

Measurements of conidia from cultures on different media are as follows:

On slightly acidified hard potato agar, culture ten days old; conidia from thin pseudopionnotes:

Conidia: 0–septate, rare
1–septate, 7 per cent, 10 x 2.4μ
2–septate, 1 per cent, 20 x 2.9μ
3–septate, 36 per cent, 36 x 3.1 (29–46 x 2.9–3.5)μ
4–septate, 20 per cent, 49 x 3.15 (40–53 x 3–4)μ
5–septate, 35 per cent, 60 x 3.8 (50–70 x 3.5–4.2)μ
6– to 9–septate, 1 per cent (60–100 x 4–5μ)

On red raspberry cane plug, culture seventy-six days old; conidia from a small sporodochium:

Conidia: 3–septate, 57 per cent, 40 x 2.7(32–45 x 2.4–3)μ
4–septate, 28 per cent, 45 x 2.9(42–52 x 2.6–3.2)μ
5–septate, 15 per cent, 50 x 2.9(43–54 x 2.7–3.2)μ

On hard lima-bean agar, culture eight days old; conidia from a thin layer near substratum:

Conidia: 1–septate, 2 per cent
2–septate, 1 per cent
3–septate, 32 per cent, 37 x 3.9 (28–43 x 3.5–5.3)μ
4–septate, 9 per cent

5–septate, 55 per cent, 54 x 4.4 (40–61 x 3.5–5.5)μ

6–septate	1 per cent	61 x 4.9 (60–70 x 4.7–5.2)μ (only four measured)
7–septate		67 x 5 (60–79 x 4.7–5.2)μ (only four measured)
8–septate		76 x 4.8 (70–79 x 4.7–4.8)μ (only three measured)

On potato tuber plug, culture twenty-four days old; conidia from a sporodochium, many spores degenerated, only normal ones measured:

Conidia: 0–septate, none
1–septate, 4 per cent
2–septate, none
3–septate, 50 per cent, 32 x 3.1 (20–40 x 2.7–3.5)μ
4–septate, 22 per cent
5–septate, 24 per cent, 42 x 3.5 (35–51 x 3–3.6)μ

On potato stem plug, culture one hundred and thirteen days old; conidia from a sporodochium:

Conidia: 3–septate, 25 per cent, about 38 x 3.3μ
4–septate, 25 per cent, about 40 x 3.4μ
5–septate, 50 per cent, 42 x 3.5 (36–46 x 3–4.1)μ

On whole steamed potato tuber, culture forty-five days old:

(1) Conidia from aërial mycelium

Conidia: A — Arthrosporial type
1–septate, 10 per cent, about 10 x 3.9μ
2–septate, 3 per cent, 16 x 4μ
3–septate, 71 per cent, 28 x 4.3 (19–37 x 4–5)μ
4–septate, 6 per cent
5–septate, 10 per cent, 41 x 4.2 (37–46 x 4.1–4.5)μ
B — Sickle-shaped type
0–septate, 6 per cent, about 10 x 2.6μ
1–septate, 22 per cent, 16 x 2.8 (13–19 x 2.4–3)μ
2–septate, 4 per cent, about 21 x 2.9μ
3–septate, 40 per cent, 30 x 3.1 (20–34 x 2.9–3.5)μ
4–septate, 12 per cent, about 39 x 3.2μ
5–septate, 16 per cent, 45 x 3.3 (38–53 x 3–3.6)μ

(2) Conidia from small sporodochia converging into a nearly continuous layer

Conidia: 3–septate, 45 per cent, 33 x 3.1 (20–41 x 2.5–3.5)μ
4–septate, 28 per cent, 40 x 3.2μ (only a few measured)
5–septate, 27 per cent, 43 x 3.3 (36–50 x 2.9–4.1)μ

On hard lima-bean agar, culture thirteen days old; conidia from pseudopionnotal stage:

Conidia: 3–septate, about 12 per cent, 48 x 3μ (only three measured)
4–septate, about 8 per cent
5–septate, 80 per cent, 61 x 3.3 (50–70 x 3.1–3.5)μ

On hard oat agar, culture thirty-seven days old; conidia from aërial mycelium close to substratum:

Conidia: 1–septate, 1 per cent
3–septate, 20 per cent, 31 x 3.3μ
4–septate, 15 per cent
5–septate, 60 per cent, 45 x 3.7 (43–49 x 3.3–4)μ
6–septate, 4 per cent, 61 x 4.2μ (only one measured)

On same medium as above, culture twenty-four days old; conidia from pseudopionnotes:

Conidia: 3–septate, 10 per cent, 28 x 3.3μ
4–septate, 4 per cent
5–septate, 50 per cent, 51 x 4μ
6–septate, 30 per cent, 60.6 x 4.2μ
7– and 8–septate, 6 per cent, 75 x 43μ

Average of the above measurements:

Conidia: 0–septate, about 0.5 per cent, 10 x 3.25μ
1–septate, about 4 per cent, 12 x 3.0μ
2–septate, about 0.5 per cent
3–septate, about 35.5 per cent, 36 x 3.2μ
4–septate, about 15 per cent
5–septate, about 44 per cent, 48.5 x 3.63μ
6– to 9–septate, about 0.5 per cent, 60–100 x 4.7–5.2μ

The most characteristic features of the fungus are as follows: 0– to 3–septate, spindle-shaped conidia of aërial mycelium; 3– to 5–septate,

very narrow sickle-shaped conidia of sporodochia, and comparatively broad and longer anguiform; 6– to 9–septate conidia of pseudopionnotal stage often occurring on various agars.

20. **Fusarium biforme** n. sp. (Figs. 1U and 17; Pl. VII, fig. 10)

Conidia of two forms: sporodochial conidia more or less uniformly ellipsoid, 3– to 5–septate, 3–septate measuring 39 x 3.3 (36–46 x 2.9–3.6) μ, 5–septate measuring 51 x 3.5 (43–60 x 3–4) μ; pseudopionnotal conidia 0– to 9– and even up to 12–septate, sometimes nearly straight or anguiform, 5–septate measuring 52 x 4.2 μ, 6– to 9–septate measuring 45–84 x 4–5.8 μ; conidia in mass typically salmon-colored; no chlamydospores; mycelium

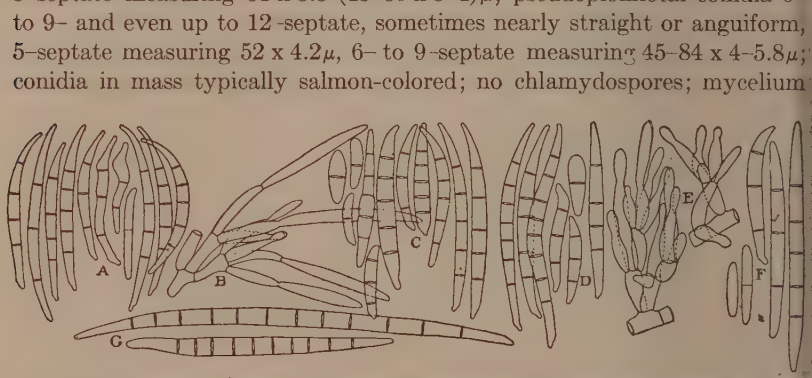


FIG. 17.—*Fusarium biforme.* A, *Conidia (sporodochium 3 millimeters in diameter),* B, *conidiophore, from 29-days-old culture on hard oat agar;* C, *conidia from aërial mycelium from 71-days-old culture on potato tuber plug;* D, *semi-pseudopionnotal conidia from 14-days-old culture on slightly acidified hard potato agar;* E, *conidiophores,* F, *typical conidia,* G, *largest and most highly septate conidia, from 10-days-old culture on rice*

well developed, uniform, white in pseudopionnotal stage and from pink to pomegranate near substratum in sporodochial stage (on hard oat agar);[42] substratum from brick red to pomegranate (on oat and other agars).

Hab. On rotted tuber of *Solanum tuberosum,* together with *F. coeruleum,* Wisconsin.

Differs from *F. diversisporum* chiefly in color of mycelium and of substratum on hard oat agar and other agars, and in absence of a uniform and typical arthrosporial stage of aërial conidia, although single conidia of that type occur here also. Differs from *F. diffusum* by the presence of 8– to 12–septate conidia.

[42] On the same medium *F. diversisporum* remains from white to clay in color.

Latin description.—Conidiis biformibus: conidiis sporodochialibus, plus minusve aequabiliter ellipsoidalibus, 3–5–septatis: 3–septatis, 39 x 3.3 (36–46 x 2.9–3.6)μ; 5–septatis 51 x 3.5 (43–60 x 3–4)μ; conidiis pseudopionnotalibus 0–9–septatis vel etiam 12–septatis, interdum prope rectis vel anguiformibus; 5–septatis, 52 x 4.2μ; 6–9–septatis, 45–84 x 4–5.8μ; conidiis in totum typice "salmon-color" (R); nullis chlamydosporis; mycelio plene maturo, uniformi, albo in pseudopionnotum gradu, ex rubello "pomegranate" (R) in gradu sporodochiali (in durae avenae agare); substrato e "brick red" (R) "pomegranate" (R) (in avenae agaribus et aliis agaribus).

Hab. In tuberibus putridis Solani tuberosi una cum F. coeruleo, Wisconsin, Amer. bor.

Measurements of the conidia on different media are as follows:

On corn agar, culture twenty-six days old; conidia from a thin layer directly on substratum;

Conidia: 1– to 4–septate, 20 per cent (about an equal number of each)
5–septate, 45 per cent, 60 x 3.6 (50–70 x 3.4–3.8)μ
6– to 9–septate, 35 per cent, 80 x 4.4 (77–88 x 4.1–4.7)μ

On hard potato agar, slightly acidified, culture fourteen days old; conidia from aërial mycelium close to substratum:

Conidia: 0–septate, 0.5 per cent, 12 x 3μ
1–septate, 3 per cent, 19 x 3μ
2–septate, rare, 25 x 3.2μ
3–septate, 5 per cent, 32 x 3.7 (24–51 x 3.5–4.2)μ
4–septate, 2.5 per cent
5–septate, 80 per cent, 51.5 x 4.3 (40–74 x 4–5.2)μ
6–septate, 6 per cent, 58 x 4.7 (50–75 x 4.3–5.3)μ
7– and 8–septate, 3 per cent, 68 x 4.7 (55–80 x 4.3–5.3)μ
9– to 11–septate, rare, 84 x 5.9μ (only a few measured)

On potato tuber plug, culture seventy-one days old; conidia from aërial mycelium close to substratum:

Conidia: 0–septate, 2 per cent, 9 x 3μ
1–septate, 6 per cent, 14 x 3.3μ, a few 15 x 5.7μ
2–septate, 3 per cent, 20 x 3.4μ
3–septate, 30 per cent, 27.5 x 3.9 (19–39 x 3.5–4.1)μ
4–septate, 12 per cent

5–septate, 44 per cent, 43 x 4.1 (31-54 x 3.9–5.2)μ
6–septate, 2 per cent, 49 x 4.3 (45–72 x 4–4.9)μ
7–septate, 1 per cent, 60 x 4.8 (59 -73 x 4.1–5.3)μ
8– and 9–septate, rare, 60–78 x 4.5–5.8μ (only a few measured)

On hard lima-bean agar with 2 per cent glucose, culture seven days old; conidia from aërial mycelium:

Conidia: 0– and 1–septate, 79 per cent
3–septate, 15 per cent, 36 x 4.6 (33–41 x 4.3–4.7)μ
4–septate, 5 per cent
5–septate, 1 per cent, 54 x 4.7 (53–66 x 4.3–5.3)μ

On hard oat agar, culture twenty-eight days old; conidia from a large (3 millimeters in diameter) sporodochium:

Conidia: 1–septate, 3 per cent, about 28 x 3 (28–37 x 2.3–3)μ
2–septate, 1 per cent
3–septate, 45 per cent, 39 x 3.3 (36–46 x 2.9–3.6)μ
4–septate, 16 per cent
5–septate, 35 per cent, 51 x 3.5 (43–60 x 3–4)μ

Average of the above measurements for all non-sporodochial conidia:

Conidia: 0–septate, about 9 per cent, 11 x 3μ
1–septate, about 11 per cent, 16.5 x 3.15μ
2–septate, about 2 per cent
3–septate, about 20 per cent, 32 x 4.1μ
4–septate, about 8 per cent
5–septate, about 41 per cent, 52 x 4.2μ
6– to 9–septate, about 9 per cent, 45–84 x 4–5.8μ

The organism when first isolated had large sporodochia (from 2 to 5 millimeters in diameter), and the substratum and mycelium near it were from rose to pomegranate in color; later the color of mycelium and substratum faded and no sporodochia were produced at all; during the last year its original characters — both color and sporodochia — reappeared. Under just what influence loss of characters and their reappearance took place the writer is unable to say, although it seems that a slightly acidified and relatively dry medium actually helped to bring the fungus to the original conditions.

21. **Fusarium anguioides** n. sp. (Figs. 1T and 18; Pl. VI, fig. 11)

Conidia of diverse type, ranging from arthrosporial (short spindle-haped, with more or less rounded ends, 0– to 3–septate) to typically lightly curved or nearly straight and anguiform, 1– to 15–septate; 1– nd 3–septate conidia typical for the first form and measuring 27 x 4.4 20–38 x 3.9–5.3)μ; for the other form the conidia commonly measuring s follows:

5–septate, 51 x 4.2 (47–68 x 3.9–4.6)μ
6– and 7–septate, 76 x 4.6 (65–86 x 4.2–5.2)μ
8– and 9–septate, 89 x 4.86 (80–102 x 4.3–5.8)μ

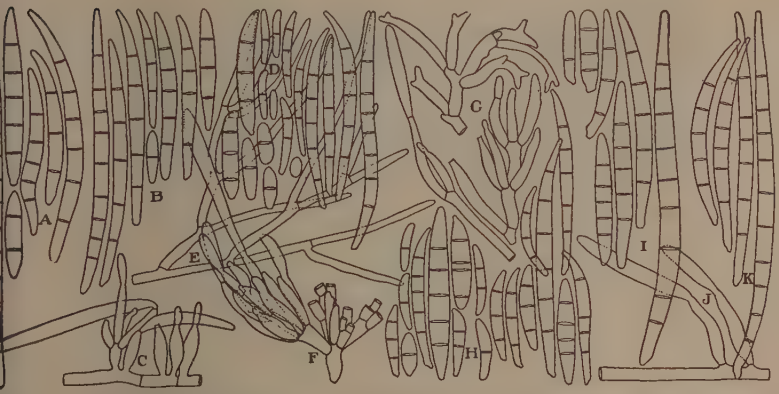


FIG. 18.— *Fusarium anguioides.* A, *Pseudopionnotal conidia from 6-days-old culture on ightly acidified hard potato agar;* B, *conidia from 15-days-old culture on wheat grain;* C, *conidio-hores from 6-days-old culture on slightly acidified hard potato agar;* D, *conidia from 46-days-d culture on wheat grain;* E, *conidiophore from 15-days-old culture on wheat grain;* F *and* G, *nidiophores,* H, *conidia, from 62-days-old culture on red raspberry cane plug;* I, *pseudopionnotal nidia from 11-days-old culture on medium potato agar;* J, *conidiophores from 62-days-old culture red raspberry cane plug;* K, *pseudopionnotal conidia from 13-days-old hard lima-bean agar*

olor of conidia in pseudopionnotal layer, on glucose potato agar, ranging om light pinkish cinnamon to cinnamon; arthrosporial conidia of com-on occurrence on aërial mycelium, but often the latter, especially on ifferent agar, nearly absent, when a thin spore layer, pseudopionnotes, produced for which anguiform conidia are typical.

Hab. On rotted tuber of *Solanum tuberosum* from Castile, New York, association with *F. arcuosporum.*

In pseudopionnotal stage *F. anguioides* is much like *F. biforme*, but has no sporodochial stage, or rather no macroscopically observable sporodochia.

Latin description.—Conidiis variis typis, interdum arthrosporialibus (brevibus, fusiformibus, terminis plus minusve rotundatis, 0–3-septatis), interdum typice paulum curvatis vel prope rectis anguiformibusque, 1–15-septatis; conidiis primo typo typice 1–vel 3–septatis, 27 x 4.4 (20–38 x 3.9–5.3)μ; conidiis altero typo: 5–septatis plerumque 51 x 4.2 (47–68 x 3.9–4.6)μ; 6–7–septatis plerumque 76 x 4.6 (65–86 x 4.2–5.2)μ; 8–9–septatis plerumque 89 x 4.86 (80–102 x 4.3–5.8)μ. Conidiis in strato pseudopionnotali, in agari glucoso Solani tuberosi e pallide "pinkish-cinnamon" (R) "cinnamon" (R); saepe conidiis arthrosporialibus in aerio mycelio, sed hoc mycelio saepe—imprimis in alio agari—prope absente, quae cum ita sint tenues sporarum strati, pseudopionnotes, oriuntur cum conidiis typice anguiformibus.

Hab. In tuberibus putridis Solani tuberosi, una cum F. arcuosporo, Castile, New York, Amer. bor.

Measurements of conidia on different media are as follows:

On red raspberry cane plug, culture sixty-two days old; conidia from aërial mycelium close to substratum:

Conidia: 0–septate, 3 per cent
1–septate, 19 per cent, 17 x 3 (12–22 x 2.5–4)μ
2–septate, 9 per cent
3–septate, 43 per cent, 30 x 3.5 (17–42 x 3–4.8)μ
4–septate, 7 per cent
5–septate, 18 per cent, 47 x 4.2 (35–55 x 3–5.2)μ, the thickest 50 x 5.9μ
6–septate, 1 per cent
7–septate, rare, the longest 75 x 4.8μ

On hard potato agar, culture eleven days old; conidia from thin pseudopionnotes:

Conidia: 1–septate, 3 per cent, 18 x 4.3μ (only a few measured)
2–septate, 2 per cent
3–septate, 20 per cent, 29 x 4.5 (20–35 x 4–6.5)μ, the broadest 34 x 6.5μ
4–septate, 10 per cent

5–septate, 44 per cent, 52 x 4.6 (33–75 x 4.1–6.2)μ

6–septate, 7–septate } 9 per cent { 72 x 5.2μ (only a few measured)

8–septate, 9–septate } 8 per cent { 80 x 5.3μ (only a few measured); 102 x 5.8μ (only a few measured, the largest 105 x 6.5μ)

11–septate, 12–septate } 4 per cent { 91 x 5.8μ (only one measured); 101 x 5.7μ (only one measured)

On hard lima-bean agar, culture thirteen days old; conidia from thin seudopionnotes:

onidia: 5–septate, 9 per cent, 58 x 4.1 (53–62 x 3.9–4.4)μ
6–septate, 12 per cent, 78 x 4.3 (70–87 x 4.1–4.5)μ
7–septate, 19 per cent, 86 x 4.3 (78–96 x 4.1–4.5)μ
8–septate, 32 per cent, 93 x 4.4 (86–100 x 4.2–4.8)μ
9–septate, 17 per cent, 94 x 4.4 (90–100 x 4.2–4.7)μ
10–septate, 7 per cent, 94 x 4.4 (97–103 x 4.3–4.5)μ (only four measured)
11–septate, 2 per cent, 108 x 4.4μ (only one measured)
12–septate, 1 per cent, 110 x 4.4μ (only one measured)
13–septate, 1 per cent, 126 x 4.8μ (only one measured)

On wheat grain, culture fifteen days old; conidia from aërial mycelium:

onidia: 0–septate, very rare
1–septate, very rare
2–septate, very rare, 26 x 3.1μ (only a few measured)
3–septate, 5 per cent
4–septate, 2.5 per cent
5–septate, 89 per cent, 60 x 4.2 (45–70 x 3.9–4.7)μ

6–septate, 7–septate } 3 per cent { 75 x 4.2 (67–80 x 4.1–4.4)μ (only a few measured); 85 x 4.3μ (only a few measured)

8–septate, 9–septate } 0.5 per cent { 81 x 4.6μ (only a few measured); 86 x 4.5μ (only a few measured, the longest 92 x 4.5μ)

On hard lima-bean agar, culture nine days old; conidia from pseudo pionnotes:

Conidia: 0–septate, 1–septate, 2–septate } 1 per cent
3–septate, 2 per cent, 45 x 4 (only a few measured)
5–septate, 40 per cent, 63 x 4.3 (43–76 x 3.5–4.7)μ
6–septate, 22 per cent, 72 x 4.4 (62–79 x 4–4.7)μ
7–septate, 18 per cent, 80 x 4.5 (63–88 x 4.3–4.8)μ
8–septate, 10 per cent, 87 x 4.7 (75–93 x 4.3–4.8)μ
9–septate, 5 per cent, 88 x 4.7μ (only two measured)
10–septate, 2 per cent, 90 x 4.8μ (only one measured)

On wheat grain, culture forty-six days old; conidia from aërial mycelium close to substratum:

Conidia: 0–septate, 3 per cent: arthrosporial, 15 x 4.1 (10–22 x 3.9–4.4)μ
sickle-shaped, 20 x 2.8 (16–22 x 2.6–3.5)μ
1–septate, 27 per cent, 2–septate, 4 per cent, 3–septate, 38 per cent } arthrosporial, 27 x 4.4 (20–38 x 3.9–5.3)μ
4–septate, 11 per cent
5–septate, 15 per cent, 53 x 3.9 (42–62 x 3.5–4.2)μ
6–septate, 2 per cent, 65 x 4.2 (54–70 x 3.9–5.2)μ
7– and 8–septate, rare, 73–81 x 4.1–4.8μ (only three measured

Average of the above measurements:

Conidia: 0–septate, 0.6 per cent
1–septate, 4.6 per cent
2–septate, 2.2 per cent
3–septate, 14 per cent
4–septate, 4 per cent
5–septate, 40 per cent, 50 x 4.2μ
6– and 7–septate, 16.8 per cent, 76 x 4.6μ
8– and 9–septate, 14.4 per cent, 89 x 4.86μ
10– to 15–septate, 3.4 per cent, 103 x 4.9μ (the largest conidium found was 15–septate, 150 x 6μ)

22. *Fusarium anguioides* var. **caudatum** n. var. (Fig. 19; Pl. VI, fig. 9) Conidial type very much the same as that of *F. anguioides*, but 8–11–septate conidia very rare and the size for the same septation newhat larger; conidia never in macroscopically observable thick eudopionnotes as is often the case in *F. anguioides* when grown on various ars. Conidia of this fungus, even in comparatively young cultures, en produce on one end a long, usually unbranched, germ tube (see tain conidia in figure 19), which has never been observed in *F. guioides*.

IG. 19.—*Fusarium anguioides var. caudatum.* A, *Pseudopionnotal conidia from 10-days-culture on slightly acidified hard potato agar;* B, *conidia from 61-days-old culture on red berry cane plug;* C, *typical,* D, *degenerated, conidia,* E, *conidiophores, from 67-days-old culture potato stem plug;* F, *conidia from 15-days-old culture on wheat grain;* G, *pseudopionnotal idia from 9-days-old culture on hard lima-bean agar;* H, *conidiophores,* I, *pseudopionnotal idia,* J, *chlamydospore-like mycelial swelling,* K, *conidiophores, from 11-days-old culture medium potato agar;* L, *pseudopionnotal conidia from 16-days-old culture on hard lima-n agar with 2 per cent glucose;* M, *pseudopionnotal conidia from 37-days-old culture on hard agar;* N, *conidiophores from 11-days-old culture on medium potato agar*

Hab. On rotted tubers of *Solanum tuberosum*, in association with *coeruleum*, Ithaca, New York.

Measurements of conidia from cultures on different media are as follows:

On red raspberry cane plug, culture sixty-one days old:

Conidia: 0– and 1–septate, 10 per cent
2– to 4–septate, 35 per cent
5–septate, 55 per cent, 56 x 4.2 (35–80 x 3.7–4.8)μ
6–septate, rare, the longest 85 x 5.2μ

On hard lima-bean agar, culture sixteen days old:

Conidia: 0–septate, 17 per cent, 13 x 2.7 (11–16 x 2.3–3.7)μ
1–septate, 18 per cent, 22 x 3.3 (18–28 x 3–4.4)μ, the broad 33 x 6.1μ
2–septate, 12 per cent
3–septate, 40 per cent, 38.5 x 4 (29–45 x 3.5–4.7)μ, the broad 33 x 6.1μ
4–septate, 3 per cent
5–septate, 7 per cent, 60 x 4.5 (52–75 x 4.1–5.4)μ
6–septate, 3 per cent, 67 x 5.2 (53–77 x 4.1–6.1)μ
7–septate, very few, 82 x 5.2μ (only one measured)
8–septate, few, 75 x 5.3 (72–88 x 5–5.6)μ (only two measur
9–septate, very few, 94 x 5.2μ (only one measured)

On hard potato agar, culture eleven days old:

Conidia: 0–septate, 12 per cent, 14 x 3.9 (8.7–20 x 2.6–4.2)μ
1–septate, 11 per cent, 17 x 4.1μ (only four measured)
2–septate, 9 per cent
3–septate, 47 per cent, 40 x 4.3 (25–53 x 3.5–5.3)μ
4–septate, 8 per cent
5–septate, 12 per cent, 66 x 4.6 (50–77 x 4–6.1)μ
6–septate, 7–septate, } 1 per cent { 79 x 5.3μ (only one measured); 85 x 5.2μ (only one measured)

On wheat grain, culture fifteen days old:

Conidia: 0–septate, 4 per cent
1–septate, 40 per cent, 24 x 3.1 (15–27 x 2.7–3.6)μ
2–septate, 10 per cent
3–septate, 42 per cent, 43 x 3.8 (36–62 x 3.5–5.2)μ
4–septate, 2 per cent
5–septate, 2 per cent, 55 x 4.1 (43–62 x 4–4 5)μ
6–septate, few, 57 x 4.3μ (only one measured)
7–septate, very few, 79 x 4.3μ (only one measured)

On hard lima-bean agar, culture nine days old:
onidia: 0–septate, 14 per cent
1–septate, 28 per cent
2–septate, 5 per cent
3–septate, 32 per cent, 44 x 3.6 (29–63 x 3–4)μ (exceptionally 4.8μ in diameter)
4–septate, 5 per cent
5–septate, 16 per cent, 65 x 3.9 (52–79 x 3.5–4.8)μ

Average of the above measurements:
onidia: 0–septate, about 10.4 per cent, 13.5 x 3.3μ
1–septate, about 20.4 per cent, 21 x 3.5μ
2–septate, about 9.2 per cent
3–septate, about 35.2 per cent, 41 x 3.9μ
4–septate, about 5.6 per cent
5–septate, about 18.4 per cent, 60.4 x 4.26μ
6– and 7–septate, about 0.8 per cent, 82 x 4.9μ
8– and 9–septate, very rare, 85 x 5.2μ

23. **Fusarium arthrosporioides** n. sp. (Figs. 1, L to P, and 20; Pl. III, figs. 3 and 4; Pl. VII, fig. 11)

Conidia of three types: (1) elliptical, apically attenuate, slightly dicellate, mostly 5–septate, 48 x 4.3 (45–55 x 4–4.7)μ; (2) arthrosporial, to 3–(5–)septate, broad spindle-shaped, 3-septate measuring about x 5.4 (19–33 x 4.7–6)μ; (3) sporotrichial, mostly 0–septate, 4.5 x 3.8 .9–9 x 2.6–8)μ. Type 1 is found mostly in pseudopionnotes, type 2 on rial mycelium, and type 3 mainly in small, dense, bushlike clusters of nidiophores, often resembling sporodochia; no true chlamydospores; rial mycelium from white to light tints of rose and salmon hues, uniform or vered with knotted, more or less large, areas; substratum from clay lor to buckthorn brown and bright red (Plate III, fig. 4). The organism cupies an intermediate position between sections Arthrosporiella and orotrichiella.

Hab. In discolored tissues of tuber of *Solanum tuberosum*, Ireland.

The organism remained for a long time in pure culture, with well-veloped aërial mycelium and with a bright red color (Plate III, fig. 4); ie dominant type of conidia was sickle-shaped, 5–septate. During the st year — the second year of its cultivation — the development of aërial ycelium has become poorer, the color of the substratum has changed to

clay color and buckthorn brown, and sporotrichic conidia are the c
monest type. Whether the organism has changed only temporarily
not is as yet unknown.[43]

Latin description.—Conidiis tribus typis: (1) conidiis ellipticis, a
attenuatis, paulum pedicellatis, plerumque 5–septatis, 48 x 4.3 (45–

FIG. 20.—*Fusarium arthrosporioides.* A, *Normal pseudopionnotal conidia,* B, *arthrospo conidia, from 14-days-old culture on hard lima-bean agar;* C, *sporodochial conidia from days-old culture on hard lima-bean agar with 2 per cent glucose;* D, *arthrosporial,* E, *norm conidia,* F, *conidiophores, from 11-days-old culture on medium potato agar;* G, *aerial coni* H, *conidiophores, from 11-days-old culture on slightly acidified hard potato agar;* I, *con and chlamydospores from 76-days-old culture on red raspberry cane plug;* J, *conidiophores f 11-days-old culture on medium potato agar;* K, *normal,* L, *arthrosporial, type of conidia,* M, *coni phores, from aerial mycelium of 16-days-old culture on hard lima-bean agar with 2 per glucose;* N, *sickle-shaped conidia,* O, *arthrosporial and sporotrichial conidia and conidiop of the sporodochial stage, from 36-days-old culture on rye grain;* P, *chlamydospores*

4–4.7)μ; (2) conidiis arthrosporialibus, 0–3(5)–septatis, latis fusif
mibus, 3–septatis circa 25 x 5.4 (19–33 x 4.7–6)μ; (3) conidiis sporo
chialibus, plerumque 0–septatis, 4.5 x 3.8 (2.9–9 x 2.6–8)μ. Typo pri
plerumque in pseudopionnotibus, typo altero in aerio mycelio, typo ter
plerumque in parvis densis fruticosis conidiophoris uveosis, saepe simili
sporodochiis; nullis veris chlamydosporis; aerio mycelio ex albo pall
roseo "salmon color" (R), uniformi vel nodosas plus minusve magnas ar

[43] In this connection see last paragraph in description of *F. biforme* (page 168).

ibente; substrato ex argillaceo "buckthorn brown" (R) vel nitide rubro
b. III, fig. 4). Fungo locum medium inter Sectiones Arthrosporiellam
Sporotrichiellam obtinente.
Hab. In textibus decoloratis Solani tuberosi tuberum, Hibernia.

Measurements on different media are as follows:

On slightly acidified hard potato agar, culture eleven days old; conidia
m aërial mycelium:
nidia: 0–septate, 0.5 per cent, 12 x 2.7μ
1–septate, 15.5 per cent, 25 x 3.8 (17–30 x 2.6–4.7)μ
2–septate, 3 per cent, 27 x 4μ
3–septate, 77.5 per cent, 35 x 3.5 (22–48 x 3–4.4)μ
4–septate, 3 per cent, 43 x 4.2 (35–50 x 3.5–4.8)μ
5–septate, 0.5 per cent, 47 x 4.4μ (only a few measured)

On hard lima-bean agar with 2 per cent glucose, culture sixteen days old:

(1) Sickle-shaped conidia:
- 0–septate, 4.7 per cent, 10 x 2.6μ (only a few measured)
- 1–septate, 4.7 per cent, 19 x 3.1 (14–24 x 2.9–3.5)μ
- 2–septate, few, 28 x 3.3μ (only a few measured)
- 3–septate, 5.9 per cent, 34 x 4 (31–40 x 3.3–4.7)μ
- 4–septate, 0.5 per cent, 43 x 4.3 (35–44 x 4.1–4.7)μ
- 5–septate, 0.6 per cent, 47 x 4.4 (43–54 x 4.1–4.8)μ

(2) Arthrosporial conidia:
- 0–septate, 13 per cent, 8.5 x 4.3 (6–12 x 3.5–6.4)μ
- 1–septate, 23.5 per cent, 15 x 4.4 (9–20 x 3.5–5.3)μ
- 2–septate, 11.7 per cent, 18 x 5.2 (13–35 x 4.7–6)μ
- 3–septate, 35.4 per cent, 25 x 5.4 (19–33 x 4.7–6)μ
- 4–septate, few, 39 x 6 (33–47 x 5–7)μ
- 5–septate, few, 46 x 5.7 (42–56 x 5.2–6)μ

The largest conidium observed was 8–septate (exceptionally close-septate), and measured 58 x 6.5μ

On potato stem plug, culture one hundred and seven days old:
Conidia: 1–septate, 52 per cent, about 13 x 3.5μ
2–septate, 7 per cent
3–septate, 31 per cent, 34 x 3.4μ
4–septate, 3 per cent, 43 x 3.6μ
5–septate, 7 per cent, 45 x 4 (40–50 x 3.4–4.3)μ

On hard lima-bean agar, culture sixty-four days old; conidia from sporodochium:
Conidia: 1–septate, 1 per cent
3–septate, 12 per cent, 26 x 3.4 (22–44 x 3–3.6)μ
4–septate, 5 per cent, 43 x 3.9μ (only two measured)
5–septate, 81 per cent, 48 x 4 (43–52 x 3.5–4.3)μ
6–septate, 1 per cent, about 50 x 4.1μ (only two measured)

On hard lima-bean agar, culture fourteen days old; conidia from a de mycelial growth at the bottom of the slant:
Conidia: 0–septate, 1.5 per cent, 13 x 4.8μ (only three measured)
1–septate, 10 per cent, 20 x 5.2 (9–27 x 4.1–7)μ
2–septate, 4 per cent, 22 x 8.3μ (only three measured)
3–septate, 38 per cent, 28 x 5.2 (19–39 x 4.3–5.9)μ
4–septate, 4 per cent
5–septate, 37 per cent, 55 x 4.7 (43–70 x 4.4–5.3)μ
6–septate, 4 per cent, 61 x 5 (54–70 x 4.8–5.3)μ
7–septate, 1.5 per cent, 69 x 5 (64–79 x 4.7–5.3)μ

On rye grain, culture thirty-six days old; conidia from a sporodochiu of sporotrichial type:
Conidia: 0–septate, 97 per cent, 4.5 x 3.8 (2.9–9 x 2.6–8)μ
1–septate, 3 per cent, 10.2 x 5.6 (8.5–14 x 4.2–6.3)μ
2–septate, rare
3–septate, rare

Average of the above measurements:
Conidia: 0–septate, 17 per cent { 4.5 x 3.8μ (sporotrichial form) / 12.1 x 3.8μ (arthrosporial form) }
1–septate, 18 per cent, 17 x 14.2μ
2–septate, 6 per cent
3–septate, 33 per cent, 25 x 5.4μ (arthrosporial form)

4–septate, 3 per cent
5–septate, 21 per cent, 48 x 4.3μ (sickle-shaped)
6–septate, 1 per cent, 55.5 x 4.55μ (sickle-shaped)
7–septate, 0.5 per cent, 69 x 5μ (sickle-shaped)

In the case of this organism, the average percentage of septation of conidia is of no value because of the great diversity of the forms occurring. Therefore it is a safer basis to consider each stage (sporodochial and from aerial mycelium) by itself separately.

FIG. 21.— *Fusarium arthrosporioides var. asporotrichius.* A, *Aërial conidia from 7-days-old culture on hard lima-bean agar with 2 per cent glucose;* B, *sporodochial conidia from 82-days-old culture on potato tuber plug;* C, D, *conidiophores, from 11-days-old culture on slightly acidified hard potato agar;* E, *aërial conidia from 25-days-old culture on potato tuber plug;* F *and* G, *conidiophores,* H, *pseudopionnotal conidia, from 11-days-old culture on slightly acidified hard potato agar;* I, *conidia from 68-days-old culture on red raspberry cane plug;* J, *arthrosporium-like, normal, conidia from aërial mycelium from 14-days-old culture on hard lima-bean agar; aërial conidia from 36-days-old culture on rye grain;* M, *sporodochial conidia from 14-days-old culture on hard lima-bean agar*

24. *Fusarium arthrosporioides* var. **asporotrichius** n. var. (Figs. 1, R and 20 and 21; Pl. VII, fig. 9)

This fungus is very much the same as *F. arthrosporioides*, but differs from the latter by typical absence of sporotrichial sporodochia and by more pronounced and common production of from medium to large (up to 3 millimeters in diameter) sporodochia with sickle-shaped, 5–septate conidia, 51.2 x 4.3 (46–59 x 4.15–4.7)μ, as dominant type.

Hab. On rotted tubers of *Solanum tuberosum* in association w *F. Solani* and *F. coeruleum*, New York State.

Measurements on different media are as follows:

On slightly acidified hard potato agar, culture eleven days old, coni from pseudopionnotes:

Conidia: 0–septate, 0.8 per cent
1–septate, 3.4 per cent, 20 x 3.3μ
2–septate, 2.5 per cent, 30 x 3.8μ
3–septate, 49 per cent, 40 x 4 (30–56 x 3–4.7)μ
4–septate, 21.8 per cent, 50 x 4.3 (43–60 x 3.9–4.5)μ
5–septate, 22.5 per cent, 53.5 x 4.4 (49–62 x 4–4.7)μ

On red raspberry cane plug, culture sixty-eight days old; conidia fr a sporodochium:

Conidia: 1–septate, very rare
2–septate, very rare
3–septate, 9 per cent, 41 x 3.7 (21–48 x 3.3–4.4)μ
4–septate, 24 per cent, 46 x 4.1 (36–60 x 3.8–4.7)μ
5–septate, 67 per cent, 51 x 4.2 (42–62 x 3.9–4.7)μ
6–septate, rare, 62–70 x 4.1–4.8μ (only a few measured)

On potato tuber plug, culture eighty-two days old; conidia from sporodochium:

Conidia: 1–septate, rare
2–septate, rare
3–septate, 6 per cent, 36 x 3.8 (25–42 x 3.5–4.1)μ
4–septate, 17 per cent
5–septate, 77 per cent, 49 x 4.2 (43–55 x 3.5–4.7)μ

On hard lima-bean agar, culture seven days old; conidia from aër mycelium:

Conidia: 0–septate, 3 per cent
1–septate, 8 per cent
2–septate, 8 per cent
3–septate, 65 per cent, 39 x 4.1 (31–67 x 3.9–5.7)μ, the longe 68 x 4.4μ
4–septate, 14 per cent, 49 x 4.7 (44–60 x 4.2–5.3)μ
5–septate, 2 per cent, 59 x 4.8 (52–63 x 4.3–5.7)μ

On potato tuber plug, culture twenty-five days old; conidia from aërial mycelium:

Conidia: 0–septate, rare, about 16 x 2.5μ
1–septate, 7 per cent, 22 x 3.7μ (only three measured)
2–septate, 6 per cent, 27 x 4.1μ (only three measured)
3–septate, 40 per cent, 35 x 4.3 (29–45 x 3.8–4.8)μ
4–septate, 28 per cent, 43 x 4.7 (35 x 49 x 4.1–5.2)μ, the broadest 51 x 5.9μ
5–septate, 19 per cent, 45 x 4.7 (40–53 x 4.3–4.9)μ
6–septate, only one observed, 78 x 5.2μ

On whole steamed potato tuber, culture forty-six days old:

(1) Conidia from a medium large (2 millimeters in diameter) sporodochium

Conidia: 1–septate, 2.5 per cent, about 16 x 3μ
2–septate, 2.5 per cent, about 28 x 3.5 (20–40 x 3.3–3.8)μ
3–septate, 31 per cent, 38.5 x 3.7 (19–44 x 3–4.1)μ
4–septate, 34 per cent, 45 x 4μ (only three measured)
5–septate, 30 per cent, 48 x 4.15 (44–53 x 3.9–4.7)μ
6–septate, very rare, 61 x 4.3μ (only one measured)

(2) Conidia from a small sporodochium

Conidia: 1–septate, 2 per cent
2–septate, rare
3–septate, 51 per cent, 40 x 3.9 (35–43 x 3–4.1)μ
4–septate, 24 per cent, 42 x 4.1 (36–50 x 3.5–4.8)μ
5–septate, 23 per cent, 46 x 4.2 (42–50 x 4–4.5)μ

On medium potato agar, culture eleven days old; conidia from pseudopionnotes:

Conidia: 3–septate, 13 per cent, 39 x 4.3 (28–48 x 3.5–4.8)μ
4–septate, 8 per cent
5–septate, 79 per cent, 48 x 4.6 (41–61 x 3.8–4.9)μ

On hard lima-bean agar, culture fourteen days old:

(1) Conidia from aërial mycelium

Conidia: 0–septate, 6 per cent, 11 x 4.6 (6–18 x 4–5.3)μ
1–septate, 13 per cent, 18 x 5 (10–25 x 4.1–5.5)μ

2–septate, 10 per cent, 24 x 5.1 (20–30 x 4.3–5.5)μ (only three measured)
3–septate, 39 per cent, 31 x 5.2 (22–43 x 4.1–6.2)μ
4–septate, 7 per cent
5–septate, 25 per cent, 56 x 4.7 (42–70 x 4–5.9)μ
6–septate, very few, 63 x 4.9μ (only one measured)

(2) Conidia from a sporodochium
Conidia: 3–septate, about 5 per cent, 36 x 3.1μ (only a few measured)
4–septate, about 5 per cent
5–septate, about 90 per cent, 58 x 4 (52–65 x 3.5–4.8)μ

On rye grain, culture thirty-six days old:
Conidia: 0–septate, 3 per cent
1–septate, 6 per cent
2–septate, 2 per cent
3–septate, 55 per cent, 38 x 3.4 (27–50 x 3–4.4)μ
4–septate, 20 per cent
5–septate, 14 per cent, 50 x 3.6 (43–60 x 3.1–4.4)μ

Average of the above measurements:
Conidia: 0–septate, 1 per cent
1–septate, 3 per cent
2–septate, 3 per cent
3–septate, 33 per cent
4–septate, 19 per cent
5–septate, 41 per cent, 51.2 x 4.3μ
6–septate, very rare

25. *Fusarium diplosporum* Cke. et Ell.

Cf. Cooke, M. C., and Ellis, J. B., Grevillea **7**:38. 1878. Saccardo, Syll. Fung. **4**:701. 1886.

The following description is from Saccardo:

"Roseum, pulvinatum; conidiis aliis fusiformibus, utrinque acutis, arcuatis, nucleatis, demum leniter 3–septatis 40μ long., aliis ellipticis, uniseptatis 18 x 8μ.

"Hab. In caulibus Solani tuberosi, New Jersey, Amer. bor."

The abbreviated, arthrosporial, uniseptate, conidia, 18 x 8μ in size, are so uncommon that there is no doubt in the writer's mind that the

organism could easily be identified when found, and thus must be recognized as a good species. The organism was not isolated by the writer.

VII. SECTION SPOROTRICHIELLA Wr. (Fig. 1Q). Wollenweber, H. W., Maine Agr. Exp. Sta., Bul. 219:256. 1913

Fusaria of this section have from pyriform to nearly globular, mostly 0–septate, microconidia. Typical sickle-shaped, septate conidia always present, at least in young artificial cultures.

Only one species of this section is presented here. This species was twice isolated from rotted potato tubers, and thus, at least in a way, may be considered as of more or less common occurrence on this substratum. There are many other Fusaria of this section reported on such substrata as corn, carnations, apples, and others, a number of which are discussed by Lewis (1913). None of the species of this section mentioned by him, however, seem to be identical with the one here reported.

Lewis (1913:257) reports that the following organisms were isolated also from potatoes: (1) *F. Poae* (Peck) Wr., (2) *F. Solani* (Mart.) Ap. et Wr., (3) *F. conglutinans* Wr., (4) *F. Helianthi* Sacc. var., (5) *F. pirinum* (Fries) Sacc., and (6) *F. orthoceras* Ap. et Wr.

Numbers 2 and 6 are described in this paper; numbers 1 and 4 are closely related to *F. sporotrichioides* n. sp., and belong to section Sporotrichiella; number 3 belongs to section Elegans and differs from *F. orthoceras* by absence of red-wine color on rice (see Wollenweber, 1913 a:30); number 5 may belong to section Arthrosporiella.

No technical description, except results of inoculations — for potatoes always negative — and certain characters of color and of colony growth, is given, and thus a proper identification is rendered impracticable.

26. **Fusarium sporotrichioides** n. sp. (Figs. 1Q and 22; Pl. III, fig. 1)

Conidia scattered in aërial mycelium or in pseudopionnotes and distinct sporodochia; of diverse type, ranging from unicellular, more or less pyriform, microconidia of sporotrichial form, to sickle-shaped, 3– to 10–septate, apically pointed, pedicellate, macroconidia; 0–septate, sporotrichial conidia average 10.5 x 6 (9.5–11.4 x 5.6–6.5)μ; sickle-shaped, 3–septate conidia average 30.4 x 3.8μ, and 5–septate average 50.5 x 4.3μ; conidia of pseudopionnotes stage resemble those of *F. anguioides*; chlamydospores often present, intercalary, commonly in small clusters;

color of aërial mycelium and of substratum from white to clay (Pl. III fig. 1) and pink, similar to the color of *F. bullatum* var. *roseum* (Pl. III fig. 2).

Hab. On rotted tubers of *Solanum tuberosum*, together with *F. Solani* and *F. oxysporum*, New York State.

Latin description.—Conidiis in aerio mycelio sparsis vel in pseudopionnotibus et sporodochiis distinctis; typis variis: interdum microconidiis unicellularibus, plus minusve pyriformibus, sporotrichialibus; interdum

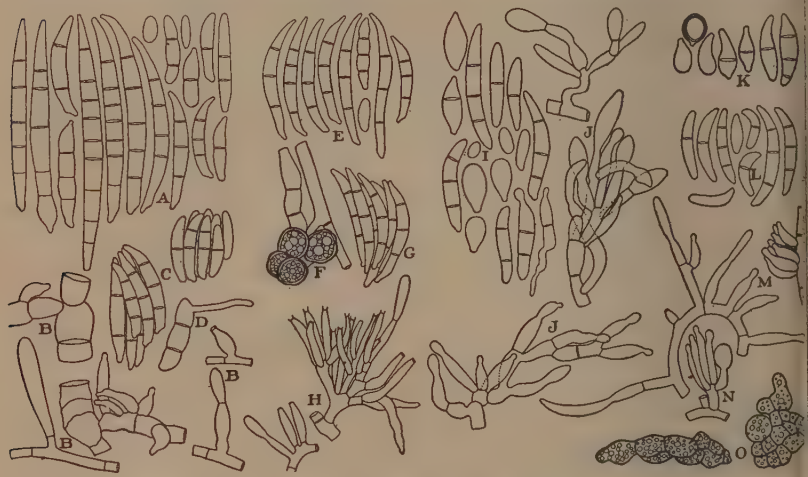


FIG. 22.—*Fusarium sporotrichioides.* A, *Pseudopionnotal conidia,* B, *various simple conidiophores,* C, *balls of conidia,* D, *germinating conidium, from 5-days-old culture on hard potato agar;* E, *sporodochial conidia,* F, *chlamydospores,* G, *ball of conidia,* H, *compound conidiophores, from 86-days-old culture on hard potato agar;* I, *sporotrichial conidia (some germinating),* J, *conidiophores, from aërial mycelium of 16-days-old culture on wheat grain;* K, *typical, thick-walled sporotrichial conidia,* L, *sickle-shaped conidia,* M, *conidiophores producing sickle-shaped conidia,* N, *conidiophore producing sporotrichial conidia,* O, *plectenchymic stroma, from 52-days-old culture on red raspberry cane plug*

macroconidiis falciformibus, 3–10–septatis, apice acutis, pedicellatis; conidiis 0–septatis sporotrichialibus plerumque 10.5 x 6 (9.5–11.4 x 5.6–6.5)μ; falciformibus, 3–septatis 30.4 x 3.8μ, et 5–septatis 50.5 x 4.3μ; conidiis pseudopionnotum gradu similibus conidiis F. anguioidum; chlamydosporis saepe visis, intercalaribus, plerumque minutis uveosis; aerio mycelio substratoque ex albo argillaceo vel rubello, simili colore F. bullati rosei.

Hab. In tuberibus putridis Solani tuberosi una cum F. Solani et F. oxysporo, New York, Amer. bor.

Measurements of conidia on different media are as follows:

On slightly acidified hard potato agar, culture five days old; conidia from pseudopionnotes:

Conidia: 0–septate, 2 per cent
1–septate, 10.5 per cent, 19 x 3.5μ
2–septate, 5.5 per cent, 28 x 3.7μ
3–septate, 37 per cent, 32.5 x 4.2 (24–50 x 3.9–4.7)μ
4–septate, 6 per cent, 45 x 4.2μ
5–septate, 33 per cent, 48 x 4.5 (40–62 x 3.9–5.3)μ
6– to 10–septate, 6 per cent, 50–90 x 5–6.1μ

On hard potato agar, culture eighty-six days old; conidia from a small sporodochium, semi-dry:

Conidia: 3–septate, nearly 100 per cent, 29.5 x 3.4 (20–41 x 3–4)μ

On red raspberry cane plug, culture fifty-two days old:

(1) Conidia of sporotrichial form

Conidia: 0–septate, 97 per cent, 9.5 x 6.5 (7–12 x 4–7.5)μ
1–septate, 3 per cent, 13.5 x 5.2 (10–15 x 4.8–6)μ
2–septate, rare
3–septate, exceptional, one measured, 21 x 5.2μ

(2) Conidia of sickle-shaped form

Conidia: 0–septate, 35 per cent, 11 x 2.9 (10–13 x 2.5–3.1)μ
1–septate, 60 per cent, 15.5 x 3.2 (12–22 x 2.9–3.5)μ
2–septate, very rare
3–septate, 5 per cent, 25 x 3.5 (20–28 x 3–4)μ

On hard lima-bean agar with 2 per cent glucose, culture 10 days old; conidia from a pseudopionnotes:

Conidia: 0–septate, 5 per cent, 10 x 3 (5.2–16 x 2.1–3.7)μ
1–septate, 15 per cent, 22 x 3.3 (16–28 x 3–3.5)μ
2–septate, 2 per cent
3–septate, 22 per cent, 33 x 3.8 (27–49 x 3.5–4.8)μ
4–septate, 23 per cent, 45 x 4 (38–49 x 3.9–4.1)μ
5–septate, 30 per cent, 51 x 4.1 (41–62 x 3.5–4.7)μ

6–septate, 1.5 per cent, 65 x 4.1 (60–80 x 3.7–4.4)μ (only four measured)
7–septate, 1.5 per cent, 67 x 4.5 (62–72 x 4.1–5.3)μ (only four measured)

On wheat grain culture sixteen days old; conidia from aërial mycelium:
(1) Sporotrichial form
Conidia: 0–septate, 70 per cent, 11.4 x 5.6 (8–16 x 4–6.5)μ
1–septate, 30 per cent, 14 x 5.6 (11–17 x 4.8–6)μ
(2) Sickle-shaped form
Conidia: 0–septate, 9 per cent, 10 x 3.2μ
1–septate, 68 per cent, 20 x 3.8 (12–24 x 3–4.2)μ
2–septate, 5 per cent
3–septate, 18 per cent, 32 x 4.3 (24–44 x 3.9–4.7)μ

Average of the above measurements:
(1) Sporotrichial form
Conidia: 0–septate, 83 per cent, 10.5 x 6μ
1–septate, 17 per cent, 14 x 5.4μ
2– and 3–septate, rare to very rare
(2) Sickle-shaped form
Conidia: 0–septate, 10 per cent
1–septate, 31 per cent, 10 x 3.1μ
2–septate, 2 per cent
3–septate, 36 per cent, 30.4 x 3.8μ
4–septate, 6 per cent
5–septate, 13 per cent, 50.5 x 4.3μ
6– to 10–septate, 2 per cent, about 67 x 4.5μ

VIII. Section **Ferruginosum** n. sec.

Conidia mostly of an intermediate type, between that of section Gibbosum and section Roseum, 3– to 7–septate; intercalary chlamydospores typically present. Substratum and basal layer of aërial mycelium varying from white when young to different hues of red at maturity.

27. **Fusarium arcuosporum** n. sp. (Figs. 1B$_1$ and 23; Pl. II, figs. 7 and 8; Pl. VI, fig. 10)

Conidia very gradually pointed toward apex, distinctly and often-

prominently pedicellate, typically much arcuate, 5–septate, 49.2 x 4 (42–54 x 3.6–4.2)μ, also often from 3– to 7–septate; single on aërial conidiophores and in from small to medium (up to 1.5 millimeters in diameter) sporodochia, the latter sometimes converging into pseudopionnotes; intercalary chlamydospores in mycelial threads typically present, though not numerous, and single or only in small clusters of from two to four cells; aërial mycelium usually well developed, uniform, white at first, then, on substrata poor in glucose, of different tints of pink with the substratum of a pomegranate color of different density; on potato agar rich in glucose, color as shown in Plate II, figures 7 and 8.

FIG. 23.—*Fusarium arcuosporum.* A, *Sporodochial conidia,* B, *conidiophore, from 20-days-old culture on hard lima-bean agar with 2 per cent glucose;* C, *conidia from small aërial sporodochium from 49-days-old culture on whole steamed potato tuber;* D, *typical conidium (the long one) and abnormal pseudopionnotal conidium from 11-days-old hard potato agar;* E, *aërial conidia,* F, *chlamydospores,* G, *conidiophores, from 75-days-old culture on red raspberry cane plug;* H, *pseudopionnotal conidia,* I, *conidiophores, from 12-days-old culture on slightly acidified hard potato agar;* J, *conidiophore,* K, *chlamydospores,* L, *conidial ball,* M, *conidiophores, from aërial mycelium from 75-days-old culture on red raspberry cane plug;* N, *chlamydospores from 173-days-old culture on corn agar;* O, *peculiarly branched,* P, *normal, pseudopionnotal conidia from 14-days-old culture on hard lima-bean agar;* Q, *conidia from aërial sporodochium of 107-days-old culture on potato stem plug;* R, *conidia from 109-days-old culture on rye straw;* S, *typical sporodochial conidium from 24-days-old culture on potato tuber plug;* T, *chlamydospores from 109-days-old culture on rye straw*

Hab. On rotted tubers of *Solanum tuberosum,* in association with *F. anguioides,* Castile, New York.

Latin description.—Conidiis maxime gradatim in apicem acutis, distincte vel saepe insignite pedicellatis, typice magnopere arcuatis, 5-septatis, 49.2 x 4 (42–54 x 3.6–4.2)μ, etiam saepe 3–7-septatis; continuis in aeriis conidiophoris vel minutis mediocribusve (usque ad $\frac{1}{5}$ mm. diam.) sporodochiis in pseudopionnotes interdum vergentibus; chlamydosporis intercalaribus sed non plurimis, continuis vel tantum minutis uveosis, 1–3-septatis; aerio mycelio fere plene maturo, uniformi, primum albo, dein, in substratis parum glucosis, rubello varie tincto, substrato "pomegranate" (R); in Solani tuberosi agare perglucoso, colore Tab. II, figg. 7, 8, exhibito.

Hab. In tuberibus putridis Solani tuberosi una cum F. anguioide, Castile, New York, Amer. bor.

Measurements of conidia on different media are as follows:

On slightly acidified hard potato agar, culture twelve days old; conidia from aërial mycelium:

Conidia: 0- and 1-septate, rare, immature
3-septate, 17 per cent, 43 x 3.5 (35–56 x 3–4.1)μ
4-septate, 19 per cent, 49 x 3.5 (38–59 x 3–4.1)μ
5-septate, 64 per cent, 54 x 3.7 (40–74 x 3–4.4)μ

On red raspberry cane plug, culture seventy-five days old; conidia from aërial mycelium:

Conidia: 3-septate, 10 per cent, 45 x 3.4 (28–51 x 3–4)μ
4-septate, 30 per cent, 50 x 3.5 (36–62 x 3–4.3)μ
5-septate, 60 per cent, 53 x 3.6 (44–62 x 3.5–4)μ

On hard lima-bean agar with 2 per cent glucose, culture seven days old; conidia from aërial mycelium:

Conidia: 3-septate, 30 per cent } (granulation of the protoplasm was too
4-septate, 15 per cent } great to clearly distinguish septation)
5-septate, 55 per cent, 53 x 3.8 (45–62 x 3.4–4.4)μ

On hard lima-bean agar with 2 per cent glucose, culture twenty days old; conidia from pseudopionnotes:

Conidia: 0-septate, rare
1-septate, rare
4-septate, 4 per cent, 47 x 4.2μ (only two measured)
5-septate, 95 per cent, 54 x 4 (47–63 x 3.5–4.8)μ
6-septate, 1 per cent, 52 x 4.1μ (only two measured)

On potato tuber plug, culture twenty-four days old; conidia from small sporodochia:

Conidia: 1–septate, 1 per cent, about 14 x 3.5μ (only one measured)
3–septate, 10 per cent, 35 x 3.6 (27–43 x 3–4.4)μ
4–septate, 12 per cent
5–septate, 77 per cent, 45 x 4 (35–51 x 3.3–4.8)μ
6– and 7–septate, rare, 52 x 4.5μ (only two measured)

On potato stem plug, culture one hundred and seven days old; conidia from aërial mycelium:

Conidia: 0–septate, rare
1–septate, 2 per cent
2–septate, rare
3–septate, 50 per cent, 31 x 3.7μ
4–septate, 25 per cent, 40 x 4μ
5–septate, 23 per cent, 42 x 4.2 (35–48 x 3.9–4.7)μ

On whole steamed potato tubers, culture forty-nine days old:

(1) Conidia from numerous small sporodochia, close to the substratum

Conidia: 3–septate, 6 per cent, about 30 x 3.5 (only a few spores measured)
4–septate, 6 per cent
5–septate, 80 per cent, 46 x 4.1 (40–53 x 3.9–4.1)μ
6–septate, 5 per cent, 54 x 4.1 (42–65 x 4–4.7)μ
7–septate, 3 per cent, 59 x 4.2 (48–65 x 4.1–4.5)μ
10–septate, only one was observed, 58 x 4.3μ (the largest)

(2) Conidia from small sporodochia, in aërial mycelium

Conidia: 3–septate, rare
4–septate, rare
5–septate, nearly 100 per cent, 51 x 4 (45–55 x 3.6–4.3)μ
6–septate, rare

On medium soft agar, culture eleven days old; conidia from aërial mycelium close to substratum:

Conidia: 1–septate, 2 per cent, 24 x 3.2 (only a few measured)
3–septate, 8 per cent, 42 x 4μ (only a few measured)
4–septate, 10 per cent
5–septate, 77 per cent, 45 x 4.1 (41–62 x 3.1–4.8)μ
6–septate, 3 per cent, 49 x 4.3μ (only a few measured)

On hard lima-bean agar, culture fourteen days old; conidia from minute converging sporodochia close to substratum:

Conidia: 3–septate, 3 per cent
4–septate, 1 per cent
5–septate, 95 per cent, 49 x 4.2 (41–63 x 3.5–5.3)μ
6–septate, 1 per cent, 54 x 4.7μ (only a few measured)

Average of the above measurements:

Conidia: 0– to 2–septate, very rare
3–septate, 13 per cent, 38 x 3.5μ
4–septate, 13.5 per cent
5–septate, 72.5 per cent, 49.2 x 4μ
6– and 7–septate, 1 per cent, 53.6 x 4.3μ

The organism occupies an intermediate position between section Roseum and section Ferruginosum; its type of conidia is that of section Roseum, while because of its true chlamydospores of only an intercalary kind it belongs to the section Ferruginosum.

An especially striking peculiarity of *F. arcuosporum* is the frequent occurrence, especially in young cultures on various agars, of conidia with more or less distinct branches and knobs (Fig. 23 o).

28. **Fusarium ferruginosum** n. sp. (Figs. 1, H to J, and 24; Pl. III, figs. 9 and 10; Pl. VI, fig. 2)

Conidia well developed, in from small to medium-sized (up to 2 millimeters in diameter) sporodochia or in pseudopionnotes, very gradually pointed toward apex, distinctly pedicellate, more or less strongly arcuate, and broader in the middle or in the lower third of their length, typically 3– to 5–septate; 5–septate average 45.3 x 4.2 (28–53 x 4.1–4.2)μ; conidia from aërial mycelium — sometimes also from sporodochia produced on very old agar cultures — typically 3–septate, 30.8 x 3.8μ, mostly apedicellate; conidia from nearly white to pale pink buff and deep vinaceous in color; intercalary chlamydospores in mycelium always present, often very numerous, in long chains and large clusters; aërial mycelium always well developed, high, often very dense, white at first changing to pink and then ferruginous when mature, the last-named color being due to production of great masses of chlamydospores; color of substratum, on

potato agar rich in glucose, at first pink, then ochraceous tawny, and finally ferruginous and Hay's russet.

Hab. On rotted tubers of *Solanum tuberosum*, Long Island, New York, on *Lycopersicum esculentum*, Virginia, and on *Panax quinquefolium*, New York State.

Latin description.—Conidiis plene maturis—sporodochiis minutis vel mediocribus (usque ad 2 mm. diam.) vel pseudopionnotibus—maxime gradatim in apicem acutis, distincte pedicellatis, plus minusve valide arcuatis, latioribus in medio vel in inferiore tertio longitudinis, typice 3–5–septatis; 5–septatis plerumque 45.3 x 4.2 (28-53 x 4.1–4.2)μ; conidiis in aerio mycelio—interdum etiam ex sporodochiis in vetustissimis agaris

FIG. 24.—*Fusarium ferruginosum.* A, *Pseudopionnotal conidia from 10-days-old culture on hard lima-bean agar;* B, *sporodochial conidia from 130-days-old culture on hard lima-bean agar with 2 per cent glucose;* C, *aërial conidia from 14-days-old culture on slightly acidified hard potato agar;* D, *pseudopionnotal conidia from 3-days-old culture on hard lima-bean agar;* E, *aërial conidia,* F, *chlamydospores, from 35-days-old culture on corn meal;* G, *conidiophores from 3-days-old culture on hard lima-bean agar*

culturis crescentibus—typice 3–septatis, 30.8 x 3.8μ, plerumque apedicellatis; conidiis ex albido pallide rubellis, gilvis atque vinaceosis; chlamydosporis intercalaribus semper in mycelio praesentibus, saepe plurimis, longis catenulatis longis uveosisque; aerio mycelio semper plene maturo, alto, semper densissimo, primum albo, dein rubello demum ferrugineo, quem colorem magnae moles chlamydosporum ortae efficiunt; substrato in agare Solani tuberosi glucoso, primum rubello, dein "ochraceous tawny" (R), demum ferrugineo et "Hay's russet" (R).

Hab. In tuberibus putridis Solani tuberosi, Long Island, New York, in Lycopersico esculento, Virginia, et in Panaci quinquefolio, New York, Amer. bor.

Measurements of conidia on different media are as follows:

On hard lima-bean agar with 2 per cent glucose, culture one hundred and thirty days old; conidia from small sporodochia produced after the culture was over eighty days old:

Conidia: 0–septate, very rare, 9 x 2.8μ
1–septate, 4 per cent, 12 x 3.2μ
2–septate, 3 per cent, 17 x 3.5μ
3–septate, 93 per cent, 27.3 x 4.1 (17–33 x 3.8–4.4)μ

On hard potato agar with 10 per cent glucose, culture seven days old in poured plate:

(1) Chlamydospores
0–septate, 10 x 9.5 (7–12.5 x 7–11.5)μ
1–septate, 16 x 11μ
(2) Conidia from aërial mycelium

Conidia: 1–septate, 1 per cent
2–septate, 1 per cent
3–septate, 88 per cent, 32 x 3.7 (25–40 x 3.1–4.2)μ
4–septate, 6 per cent
5–septate, 4 per cent, 38 x 4.1 (35–42 x 3.9–4.4)μ

On hard lima-bean agar, culture three days old; conidia from pseudopionnotes (near the center of inoculation):

Conidia: 3–septate, 66 per cent, 36 x 3.9 (30–41 x 3.5–4.3)μ
4–septate, 20 per cent
5–septate, 14 per cent, 45 x 4.2 (42–56 x 3.9–4.7)μ

On corn meal agar, culture thirty-five days old:

(1) Chlamydospores typically in chains, 8.5 (5.8–15)μ in diameter
(2) Conidia from aërial mycelium

Conidia: 0–septate, 20 per cent, 8.8 x 2.6 (7–12 x 2.4–3)μ
1–septate, 46 per cent, 12.8 x 2.9 (9–19 x 2.5–3.1)μ
2–septate, 6 per cent
3–septate, 26 per cent, 20.4 x 3.4 (17–30 x 3–3.8)μ
4–septate, 2 per cent, 26.7 x 3.9 (24–29 x 3.7–4)μ

On hard lima-bean agar, culture ten days old; conidia from pseudopionnotes:

Conidia: 3–septate, 8 per cent, 41 x 3.9μ
4–septate, 12 per cent, 45.5 x 4μ

5–septate, 80 per cent, 53 x 4.2 (50–58 x 4.1–4.4)μ, the largest observed being 65 x 4.1μ

On slightly acidified hard potato agar, culture fourteen days old; conidia from aërial mycelium:

Conidia: 0–septate, 26 per cent, 10 x 2.5 (8–14 x 1.7–3.5)μ
1–septate, 41.5 per cent, 17.3 x 3 (14–20 x 2.5–3.5)μ
2–septate, 10 per cent, 19.5 x 3.2 (15–31 x 2.9–4)μ
3–septate, 17.5 per cent, 28 x 3.6 (19–42 x 2.9–4.7)μ
4–septate, 3 per cent
5–septate, 2 per cent } 38 x 4.2 (30–45 x 3.9–5.2)μ

Average of the above measurements:

Conidia: 0–septate, 7.5 per cent, 9.4 x 2.55μ
1–septate, 14.5 per cent, 13 x 3μ
2–septate, 3 per cent
3–septate, 48 per cent, 30.8 x 3.8μ
4–septate, 10 per cent, 38.8 x 4.03μ
5–septate, 17 per cent, 45.3 x 4.2μ

The organism was isolated only once from potato tubers, but it was isolated by the writer from a specimen of Rhizoctonia-infected tomato plant also, from Virginia, and by C. O. Dalrymple from ginseng garden soil in New York State. This seems to be a cosmopolitan species.

29. **Fusarium sanguineum** n. sp. (Fig. 25; Pl. III, figs. 7 and 8; Pl. VI, fig. 1)

Conidia typically strongly arcuate, gradually pointed toward apex, distinctly pedicellate, 3– to 5–septate — 3–septate conidia averaging 33.5 x 3.6 (24–37 x 3.4–3.8)μ and 5–septate averaging 45.2 x 4.1 (40–47 x 3.9–4.2)μ — single, in from small to medium-sized (up to 2 millimeters in diameter) sporodochia and in pseudopionnotes, the latter form of fructification dominant on most media, especially on agars; chlamydospores almost always present, intercalary in conidia and in mycelial threads, borne singly, in chains and in clusters; aërial mycelium seldom well developed and then from white to different shades of pink, on various agars mostly absent leaving exposed pseudopionnotes of ox-blood red color.

Hab. On rotted tubers of *Solanum tuberosum* in association with *F. lutulatum* var. *zonatum*, Ithaca, New York.

Latin description.—Conidiis typice valide arcuatis, gradatim in apicem acutis, distincte pedicellatis, 3–5–septatis — conidiis 3–septatis, 33.5 x 3.6 (24–37 x 3.4–3.8)μ, conidiis 5–septatis, 45.2 x 4.1 (40–47 x 3.9–4.2)μ — continuis, minutis vel mediocribus (usque ad 2 mm. diam.) sporodochiis et pseudopionnotibus, quo fructificationis modo in plurimis mediis frequentissimo imprimis in agaribus; chlamydosporis plerumque praesentibus, intercalaribus in conidiis et in hyphis, singulatim ortis, catenulatis vel uveosis; aerio mycelio raro plene maturo, sed, cum plene maturum, tum

FIG. 25.—*Fusarium sanguineum.* A, *Pseudopionnotal conidia (one chlamydospore-like conidium) from 8-days-old culture on hard lima-bean agar with 2 per cent glucose;* B, *pseudopionnotal conidia from 14-days-old culture on hard lima-bean agar;* C, *typical conidium from 47-days-old culture on whole grains of wheat;* D, *pseudopionnotal conidia from 19-days-old culture on slightly acidified hard potato agar;* E, *pseudopionnotal conidia from 23-days-old culture on red raspberry cane plug;* F, *conidia,* G, *chlamydospores, from 76-days-old culture on potato tuber plug;* H, *conidiophores from 23-days-old culture on red raspberry cane plug;* I, *chlamydospores from 176-days-old culture on corn agar;* J, *sporodochial conidia from 41-days-old culture on rye straw;* K, *conidia from 176-days-old culture on corn meal;* L, *conidiophores from 47-days-old culture on whole grains of wheat*

ex albo varie rubello tincto, in agaribus variis plerumque absente, pseudopionnotes "ox-blood red" (R) exponente.

Hab. In tuberibus putridis Solani tuberosi una cum F. lutulato var. zonato, Ithaca, New York, Amer. bor.

Measurements of conidia on different media are as follows:

On red raspberry cane plug, culture twenty-three days old:

(1) Conidia from pseudopionnotes

Conidia: 1–septate, 7 per cent, 15 x 2.3 (10–23 x 2.2–2.5)μ
2–septate, 2.5 per cent
3–septate, 17 per cent, 32 x 3.4 (22–43 x 2.8–4.1)μ
4–septate, 7 per cent, 40 x 3.8 (35–45 x 3–4.3)μ
5–septate, 63.5 per cent, 47 x 4.2 (38–51 x 3.9–4.3)μ
6–septate, 3 per cent, 52–60 x 4.1–4.4μ (only a few measured)
7–septate, very few, 52–60 x 4.1–4.4μ (only a few measured, the thickest, swollen, 6.2μ in diameter)

(2) Chlamydospores

(a) Unicellular, in conidia, 6–12.5 x 6–8μ
(b) Unicellular, in mycelium, 8–17 x 7–14μ

On slightly acidified hard potato agar, culture nineteen days old; conidia from pseudopionnotes:

Conidia: 1–septate, 1 per cent
2–septate, 2 per cent
3–septate, 57 per cent, 37.5 x 3.6 (32–50 x 3–4)μ
4–septate, 17 per cent, 44 x 3.7 (38–60 x 3.5–4.4)μ
5–septate, 20 per cent, 45 x 4.1 (40–60 x 3.8–4.4)μ
6–septate, 7–septate } 3 per cent

On potato tuber plug, culture seventy-six days old; conidia from aërial mycelium:

Conidia: 0–septate, 5 per cent
1–septate, 15 per cent
2–septate, 10 per cent
3–septate, 55 per cent, 24 x 3.5 (17–35 x 3–4)μ
4–septate, 7 per cent
5–septate, 8 per cent, 40 x 4.1 (35–43 x 3.5–4.4)μ

On hard lima-bean agar with 2 per cent glucose, culture eight days old; conidia from pseudopionnotes:

Conidia: 3–septate, 3 per cent, 41 x 3.8 (35–44 x 3.5–4.1)μ
4–septate, 5 per cent
5–septate, 90 per cent, 47 x 4.2 (43–51 x 3.9–4.7)μ
6–septate, 2 per cent

On hard lima-bean agar, culture sixteen days old, most of the conidia swollen (only normal, not swollen, conidia, were measured):

Conidia: 1–septate, 9 per cent, 14.7 x 2.5 (12–19.5 x 2.3–3)μ
2–septate, very rare
3–septate, 37 per cent, 33 x 3.5 (18–41 x 3–4.1)μ
4–septate, 14 per cent
5–septate, 29 per cent, 47 x 3.9 (38–56 x 3.5–4.4)μ
6–septate, 7 per cent, 50 x 4 (43–58 x 3.9–4.4)μ
7–septate, 4 per cent, 50 x 4.1 (49–56 x 4–4.3)μ
8–septate, exceptional, 61 x 4.4μ (only one found and measured)

Average of the above measurements:

Conidia: 0–septate, 1 per cent
1–septate, 6 per cent
2–septate, 3 per cent
3–septate, 34 per cent, 33.5 x 3.6μ
4–septate, 10 per cent
5–septate, 42 per cent, 45.2 x 4.1μ
6– and 7–septate, 4 per cent, 50 x 4.05μ
8–septate, very rare, 61 x 4.4μ (only one measured)

30. *Fusarium sanguineum* var. **pallidium** n. var. (Figs. 1K and 26; Pl. III, figs. 5 and 6; Pl. VII, fig. 7)

Differs from *F. sanguineum* by better development of mycelium, by much slower rate of colony growth, by paler color of substratum and conidia (Pl. III, figs. 5 and 6), and by chlamydospores which are intercalary, as in *F. sanguineum*, but mostly in conidia and not in mycelium, and of much rarer occurrence than in *F. sanguineum*.

Hab. On rotted tubers of *Solanum tuberosum*, in association with *F. oxysporum*, South Dakota.

Measurements of conidia on different media are as follows:

On slightly acidified hard potato agar, culture three days old; conidia from pseudopionnotes:

Conidia: 2–septate, rare
3–septate, 53 per cent, 45 x 3.9 (38–56 x 3.5–4.1)μ
4–septate, 20 per cent, 40 x 4 (40–57 x 3.9–4.1)μ
5–septate, 20 per cent, 53 x 4.1 (47–60 x 3.9–4.3)μ
6– and 7–septate, 7 per cent, 55 x 4.3 (52–61 x 4.1–4.8)μ

On red raspberry cane plug, culture thirty-two days old; conidia from aërial mycelium:

Conidia: 1–septate, few
3–septate, 43 per cent, 30 x 3.8 (19–42 x 2.6–4.3)μ
4–septate, 36 per cent, 36 x 4 (31–42 x 3.5–4.3)μ
5–septate, 21 per cent, 39 x 4.1 (33–43 x 3.9–4.7)μ

On hard lima-bean agar with 2 per cent glucose, culture eight days old; conidia from pseudopionnotes:

Conidia: 3–septate, 60 per cent, 41 x 3.7 (35–48 x 3.5–4.1)μ
4–septate, 25 per cent, 51 x 3.8 (44–60 x 3.5–4.1)μ
5–septate, 15 per cent, 55 x 3.8 (52–56 x 3.5–4)μ

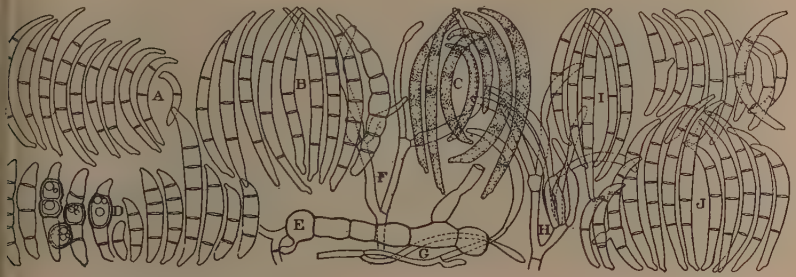


FIG. 26.— *Fusarium sanguineum var. pallidium.* A, *Pseudopionnotal conidia from 32-days-old culture on red raspberry cane plug;* B, *pseudopionnotal conidia from 3-days-old culture on slightly acidified hard potato agar;* C, *pseudopionnotal conidia with densely granulated content and indistinct septation from 8-days-old culture on hard lima-bean agar with 2 per cent glucose:* D, *conidia (normal, swollen, and with chlamydospores) from aërial mycelium from 35-days-old culture on whole steamed potato tubers;* E, *chlamydospore-like swellings in mycelium from 176-days-old culture on corn agar;* F, G, H, *conidiophores from 14-days-old culture on hard lima-bean agar;* I, *pseudopionnotal conidia from 35-days-old culture on whole steamed potato tubers;* J, *pseudopionnotal and aërial conidia from 14-days-old culture on hard lima-bean agar*

On whole steamed potato tuber, culture thirty-eight days old:

(1) From a tuft of conidiophores over dry surface of the tuber;[44] type of spores very much like that of *F. discolor* var. *triseptatum*

Conidia: 1–septate, 2 per cent
2–septate, 7 per cent, about 17 x 3.6μ
3–septate, 72 per cent, 24 x 4.5 (19–32 x 4–4.8)μ

[44] This type is very different from the general type, and therefore was not taken into account for average size of conidia.

4–septate, 15 per cent, 26 x 4.7 (24–30 x 4.6–5.2)μ
5–septate, 4 per cent, 28 x 4.7 (26–32 x 4.2–5.2)μ, the large 45.5 x 5.2μ

(2) From pionnotes over the cut surface of the tuber; spore type clo to that of *F. arcuosporum*

Conidia: 3–septate, 68 per cent, 41 x 3.2 (29–48 x 2.9–3.5)μ
4–septate, 20 per cent, 44 x 3.4 (36–51 x 3.2–4)μ
5–septate, 12 per cent, 48 x 3.4 (40–57 x 3–3.7)μ

On hard lima-bean agar, culture fourteen days old; conidia fro pseudopionnotes:

Conidia: 1–septate, 2 per cent, 21 x 2.8μ (only three measured)
2–septate, exceptional
3–septate, 83 per cent, 37 x 3.5 (33–42 [61 exceptional] x 3–3.9)
4–septate, 12 per cent
5–septate, 3 per cent, 47 x 3.8 (42–60 x 3.5–4)μ

On the same medium and of the same age as the above, but from a semi-dry minute sporodochium near the upper margin of the slant:

Conidia: 1–septate, 1 per cent
3–septate, 56 per cent, 43 x 3.8 (37–48 x 3.5–4.1)μ
4–septate, 29 per cent
5–septate, 14 per cent, 44 x 3.9 (40–49 x 3.5–4.2)μ

31. **Fusarium bullatum** n. sp. (Figs. 1A$_1$ and 27)

Conidia typically somewhat less arcuate than the other species of the same section, less pointed toward the apex, and broader, usually distinctly pedicellate, mostly 5–septate, 42 x 4.3 (31–47 x 4.1–4.9)μ, from pale cream to salmon in color; chlamydospores intercalary in mycelium, mostly in chains and from small to large clusters; aërial mycelium nearly always well developed, of uniform medium height and density, nearly pure white in color; substratum on various agars from colorless to a tint of light buff.

Hab. On rotted tuber of *Solanum tuberosum*, together with *F. bullatum* var. *roseum* and with *F. oxysporum* var. *resupinatum*, in Iowa.

Latin description.—Conidiis typice paulo minus arcuatis quam ceteris eadem sectionis speciebus, minus in apicem acutis, latioribus, plerumque distincte pedicellatis, plerumque 5–septatis, 42 x 4.3 (31–47 x 4.1–4.9)μ, pallide "cream color" (R) "salmon color" (R); chlamydosporis interstitialibus in mycelio, plerumque catenulatis, parvis vel magnis uveosis; in vetulo mycelio semper plene maturo, uniformi mediocri altitudine atque densitate, ferme pure albo; substrato in agaribus variis ex hyalino pallide isabelleolo tincto.

Hab. In tuberibus putridis Solani tuberosi una cum F. bullato var. laneo et cum F. oxysporo var. resupinato, Iowa, Amer. bor.

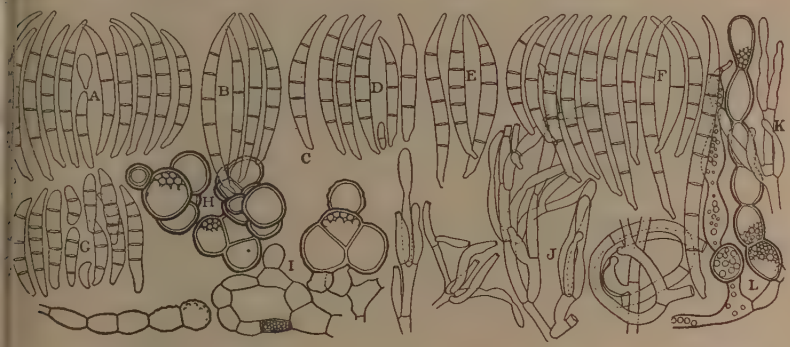


FIG. 27.—*Fusarium bullatum.* A, *Pseudopionnotal conidia from 10-days-old culture on red lima-bean agar:* B, *pseudopionnotal conidia from 77-days-old culture on red raspberry cane plug;* C, *a typical conidium from 51-days-old culture on potato tuber plug;* D, *conidia from 7-days-old culture on potato tuber plug;* E, *conidia from 19-days-old culture on hard lima-bean agar;* F, *pseudopionnotal conidia from 7-days-old culture on hard potato agar;* G, *conidia,* H, *chlamydospores, from 42-days-old culture on rye straw;* I, *chlamydospores from 77-days-old culture on red raspberry cane plug;* J, *conidiophores from 7-days-old culture on hard potato agar; conidiophore from 10-days-old culture on hard lima-bean agar;* L, *chains of chlamydospores from 175-days-old culture on corn agar*

Measurements of conidia on different media are as follows:

On slightly acidified hard potato agar, culture seven days old; conidia from pseudopionnotes:

conidia: 3–septate, 16 per cent, 36 x 3.8 (29–50 x 3.5–4.9)μ
4–septate, 19 per cent, 43 x 4.1 (33–50 x 3.9–4.9)μ
5–septate, 65 per cent, 45 x 4.4 (37–63 x 4.1–4.9)μ
6– to 8–septate, rare, 65 x 4.9 (60–82 x 4.7–5.3)μ

On red raspberry cane plug, culture seventy-seven days old; con from aërial mycelium close to substratum:

Conidia: 3–septate, 25 per cent
4–septate, 20 per cent
5–septate, 55 per cent, 48 x 4.1 (42–53 x 3.5–4.4)μ

On potato tuber plug, culture seventy-six days old; conidia from aë mycelium:

Conidia: 1–septate, 5 per cent
2–septate, 10 per cent
3–septate, 45 per cent, 31 x 3.7 (22–39 x 3.5–4.6)μ
4–septate, 20 per cent
5–septate, 20 per cent, 39 x 4.2 (35–45 x 4–4.4)μ

Same as preceding, culture eighty days old; conidia from aërial myceliu

Conidia: 0–septate, 1 per cent
1–septate, 4 per cent
2–septate, 1 per cent
3–septate, 40 per cent, 30 x 3.7 (22–39 x 3.1–4.1)μ
4–septate, 20 per cent
5–septate, 34 per cent, 41 x 4.2 (35–49 x 3.5–4.7)μ
6– to 9–septate, rare (the largest, 9–septate, 56 x 5.7μ)

On hard lima-bean agar with 2 per cent glucose, culture nineteen da old; conidia from pseudopionnotes:

Conidia: 3–septate, 2 per cent, 35 x 3.8μ (only three measured)
4–septate, 1 per cent, 38 x 3.9μ (only four measured)
5–septate, 97 per cent, 47 x 4.4 (43–54 x 4–4.7)μ
6–septate, rare, 51 x 4.5μ (only three measured, 48–53 x 4.
4.8μ)

On potato stem plug, culture one hundred and fourteen days ol conidia from aërial mycelium:

Conidia: 3–septate, 16 per cent
4–septate, 14 per cent
5–septate, 70 per cent, 41 x 4.35 (36–46 x 4–4.7)μ

On hard lima-bean agar, culture ten days old; conidia from pseudopionides:

Conidia: 0–septate, rare
1–septate, 5 per cent
2–septate, rare
3–septate, 15 per cent
4–septate, 10 per cent
5–septate, 70 per cent, 43 x 4.1 (35–50 x 3.8–4.7)μ

In some cases 5–septate conidia were up to 100 per cent, in others conidia of lower septation were as high as 50 per cent. Of the smaller, 3–septate conidia were dominant.

On rye straw, culture fifty days old; conidia from aërial mycelium close to substratum:

Conidia: 3–septate, 10 per cent
4–septate, 5 per cent
5–septate, 85 per cent, 31.25 x 4.1 (27–36 x 3.9–4.6)μ

Average of the above measurements:

Conidia: 0–septate, rare
1–septate, 2 per cent
2–septate, 1.5 per cent
3–septate, 21 per cent, 33 x 3.75μ
4–septate, 15 per cent
5–septate, 60.5 per cent, 42 x 4.3μ
6– to 8–septate, very rare, 58 x 4.7μ

32. *Fusarium bullatum* var. **roseum** n. var. (Fig. 28; Pl. III, fig. 2)

Differs from *F. bullatum* mainly by its red substratum (on agar rich in lucose, see Plate III, figure 2) and by higher septation of conidia.

Hab. Same as that of *F. bullatum*.

This organism and *F. bullatum* are in general, especially in minute details of the character of the mycelium and in the chlamydospores, very much alike, and both were isolated from the same planting of diseased tissue of a rotted potato tuber and separated out on the first dilution. It is possible that they represent an example of a sudden and permanent variation of one Fusarium in pure culture.

IX. SECTION ELEGANS Wr., Phytopath. 3:28, fig. 1, E, F, S, T, U, V. 1

Fusaria with ellipsoidal, 0– and 1–septate, microconidia; macrocon typically 3–septate, often also 4– or 5–septate, more or less gradu pointed toward apex, pedicellate; chlamydospores intercalary and term in and on mycelial hyphæ, always present, and often also in and on nidia: color of conidia mostly pinkish buff; color of substratum, and aërial mycelium when present (on potato agar rich in glucose and rice), typically of various vinaceous hues, from light pinkish to de purple.

FIG. 28.— *Fusarium bullatum var. roseum.* A, *Pseudopionnotal conidia from 7-days- culture on slightly acidified hard potato agar;* B, *pseudopionnotal conidia from 9-days-old cult on hard lima-bean agar;* C, *pseudopionnotal conidia from 12-days-old culture on hard lima-b agar;* D, *sporodochial conidia from 71-days-old culture on potato stem plug;* E, *pseudopionn conidia (many are swollen and with oil drops) from 35-days-old culture on corn meal;* F, *coni from 37-days-old culture on hard oat gar;* G, *conidia from 67-days-old culture on red raspbe cane plug;* H, *pseudopionnotal conidia from 16-days-old culture on hard lima-bean agar (two at the left typical for older growth, the one at the right for young growth);* I, *chlamydospo intercalary in chains and in clusters, from 67-days-old culture on red raspberry cane pl* J, *chlamydospores from 12-days-old culture on hard lima-bean agar;* K, L, M, *conidiopho from 7-days old culture on slightly acidified hard potato agar;* N, *conidiophores from 12-days- culture on hard lima-bean agar;* O, *conidiophores from 35-days-old culture on corn meal*

33. *Fusarium orthoceras* Ap. et Wr. (Figs. 1, I_1 to K_1, and 29)

Appel, O., and Wollenweber, H. W. Arb. K. biol. Anst. Land- u. Fo st 8:141–156; Pl. I, figs. 60 to 64; Pl. III, fig. 2. 1910. Wollenweber, H. W Phytopath. 3:30, fig. 1s. 1913.

Microconidia always greatly in excess; macroconidia ranging from rare to several per cent of the total number of conidia, mostly nearly straight, sometimes slightly curved, typically 3–septate, 36 x 3.85 (25–40 x 3.2–4)μ; aërial mycelium usually well developed, from white to a tint of olive-buff; substratum, on potato agar rich in glucose, colorless at first, then from russet vinaceous to deep brownish vinaceous; no sporodochia; no pseudopionnotes; no sclerotia. Not the same as *F. oxysporum*.

Hab. Roots and tubers of Solanaceæ, also on various other hosts and in soil, in Europe and North America.

The organism was not isolated by the writer. The original culture was obtained from the Centralbureau der Association Internationale

FIG. 30.—*Fusarium angustum.* A, *Pseudopionnotal conidia from 4-days-old culture on slightly acidified hard potato agar;* B, *conidiophores from surface of the exposed substratum from 25-days-old culture on corn agar;* C, *pseudopionnotal conidia from 9-days-old culture on hard lima-bean agar with 2 per cent glucose;* D, *pseudopionnotal conidia from 8-days-old culture on hard lima-bean agar;* E, *microconida from aërial mycelium;* F, *chlamydospores from 74-days-old red raspberry cane plug;* G, *conidiophores from 9-days-old culture on hard lima-bean agar with 2 per cent glucose*

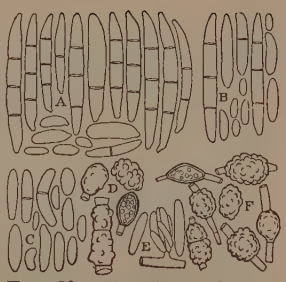


FIG. 29.—*Fusarium orthoceras.* A, *Conidia from 18-days-old culture on slightly acidified hard potato agar;* B, *conidia from 26-days-old culture on potato tuber plug;* C, *conidia from 15-days-old culture on hard lima-bean agar with 2 per cent glucose;* D, *chlamydospores from 18-days-old culture on slightly acidified hard potato agar;* E, *conidia, some in a ball, with conidiophore of common type, from 30-days-old culture on corn agar;* F, *chlamydospores from 53-days-old culture on potato tuber plug*

des Botanistes, Amsterdam, Holland, and was studied in conjunction with the other Fusaria. The above description is in the main the same as that given by Wollenweber.

34. **Fusarium angustum** n. sp. (Figs. 1, G_1 and H_1, and 30)

Conidia gradually pointed toward apex, from slightly curved to nearly straight or an-

guiform, usually distinctly pedicellate, mostly 3–septate, 45.64 x 3.5 (42–49 x 3.3–3.6)μ, often 0– to 5–septate, sometimes 6– to 8–septate on various agars usually producing thin pseudopionnotes, otherwise very similar to *F. oxysporum.*

Hab. In discolored fibrovascular bundles of tubers of *Solanum tuberosum*, Ithaca, New York.

Latin description.—Conidiis gradatim in apicem acutis, paulum curvatis vel prope rectis anguiformibusque, plerumque distincte pedicellatis, plerumque 3–septatis, 45.64 x 3.52 (42–49 x 3.3–3.6)μ, saepe 0–5–septatis, interdum 6–8–septatis; in variis agaribus tenues pseudopionnotes plerumque exhibentibus, aliter simillimis F. oxysporo.

Hab. In tuberum fasciculis decoloratis fibro-vascularibusque Solani tuberosi, Ithaca, New York, Amer. bor.

Measurements of conidia on different media are as follows:

On slightly acidified hard potato agar, culture four days old; conidia from pseudopionnotes:

Conidia: 0–septate, 6 per cent, 12 x 2.5 (8–18 x 1.8–3.5)μ
1–septate, 7 per cent, 32 x 2.9 (19–52 x 2.5–4.2)μ
2–septate, 2 per cent, 32 x 2.7 (30–39 x 2.5–3)μ
3–septate, 44 per cent, 42.2 x 3.3 (31–69 x 2.5–4.4)μ
4–septate, 13 per cent, 60.4 x 3.8 (47–70 x 3.5–4.4)μ
5–septate, 27 per cent, 63 x 3.9 (43–81 x 3.5–4.1)μ
6– to 8–septate, 1 per cent, 90 x 4.1 (80–102 x 4–4.4)μ

On red raspberry cane plug, culture seventy-four days old:

Conidia: 0–septate, 90 per cent
1–septate, 7 per cent
3–septate, 3 per cent, 39.4 x 3.81 (30–50 x 3–4.8)μ

On hard lima-bean agar with 2 per cent glucose, culture nine days old; conidia from pseudopionnotes:

Conidia: 0–septate, 54 per cent, 10 x 2.8 (5–15 x 2.7–3.1)μ
1–septate, 7 per cent, 18 x 2.9 (15–22 x 2.7–3.1)μ
2–septate, 3 per cent
3–septate, 20 per cent, 43 x 3.6 (29–53 x 3–4.1)μ
4–septate, 8 per cent
5–septate, 8 per cent, 59 x 4.5 (52–70 x 3.9–4.8)μ
6–septate, few, 70 x 4.7μ (only one measured)

On hard lima-bean agar, culture eight days old; conidia from pseudo-onnotes (measurements made in April):

onidia: 0–septate, 39 per cent, 11 x 2.6 (8.7–14 x 2.1–3.2)μ
1–septate, 17 per cent, 18 x 3.2 (14–23 x 2.9–3.9)μ
2–septate, 3 per cent, 24 x 3.3μ (only four measured)
3–septate, 32 per cent, 49 x 3.6 (42–55 x 3.5–4.8)μ
4–septate, 2 per cent, 53 x 4μ (only four measured)
5–septate, 6 per cent, 58 x 4.3 (52–65 x 3.5–4.8)μ
6–septate, 1 per cent, 73 x 4.7μ (only one measured)

On same media, culture nine days old (measurements made in May):

onidia: 0–septate, 11 per cent, 10 x 2.5 (5–15 x 1.6–3.3)μ
1–septate, 9 per cent, 17 x 3.1 (12–24 x 2.6–4)μ
2–septate, 1 per cent
3–septate, 43 per cent, 49 x 3.6 (31-54 x 2.7–4.1)μ
4–septate, 13 per cent
5–septate, 23 per cent, 50 x 4 (54–71 x 3.5–4.7)μ

Average of the above measurements:

onidia: 0–septate, 27.5 per cent, 11 x 2.6μ
1–septate, 10 per cent, 21 x 3μ
2–septate, 2 per cent, 28 x 3μ
3–septate, 35 per cent, 45.64 x 3.52μ
4–septate, 9 per cent, 56.7 x 3.9μ
5–septate, 16 per cent, 60 x 4.2μ
6–septate, 0.5 per cent, 78 x 4.5μ
8–septate, very rare, 78 x 4.5μ

35. *Fusarium redolens* Wr.[45] var. **Solani** n. var. (Figs. 1P$_1$ and 31; Pl. II, igs. 3 and 4; Pl. V, fig. 2)

Macroconidia typically more or less gradually attenuate, sometimes suddenly constricted at the apex, pedicellate, typically broader toward and

[45] *Fusarium redolens* Wr. is described by its author (see Wollenweber, Phytopath. 3: 29–30. fig. 1 E, 913) as follows: "Differs from all the above-mentioned species [*F. oxysporum*, *F. tracheiphilum*, *F. asinfectum*, *F. vasinfectum* var. *inodoratum*, *F. lycopersici*, and *F. niveum*] in the large size of its triseptate onidia, 30–40 x 4.5–5.5μ, and in the color of the brownish white conidial masses. A lilac odor is produced n rice and milk. No blue sclerotia. Vascular parasite, cause of wilt and foot disease of *Pisum sativum*. Distribution unknown."

more curved near apex, 3–septate, 36.4 x 4.86 (31–41 x 4.3–5)μ, oft also 4– and 5–septate, usually in numerous from small to medium (up $2\frac{1}{2}$ millimeters, commonly $\frac{1}{2}$ millimeter, in diameter) sporodoch sometimes, especially on different agars and in an early stage of cultu growth, in pseudopionnotes; from nearly white in color when in sm powdery masses, to a bright orange color when in comparatively lar sporodochia on nearly dry potato stems; mostly, however, from a lig pinkish cinnamon to a pinkish buff; aërial mycelium sometimes mediu well developed but usually very scant, short, from white to somewhat gra ish or brownish gray in color (Pl. II, fig. 3); color of substratum, on ag rich in glucose, as shown on Plate II, figure 4, which is different from the other Fusaria of the section Elegans.

FIG. 31.—*Fusarium redolens var. Solani.* A, *Chlamydospores produced by conidia a mycelium from 120-days-old culture on potato stem plug;* B, *conidiophores from 14-days-o culture on slightly acidified hard potato agar;* C, *anastomosed conidia from 13-days-old cultu on hard lima-bean agar;* D, *sporodochial conidia from 35-days-old culture on potato stem plu* E, *pseudopionnotal conidia,* F, *conidiophores, from 14-days-old culture on slightly acidifi hard potato agar;* G, *sporodochial conidia from 63-days-old culture on whole grain of rye;* H, *norm pseudopionnotal conidia from 13-days-old culture on hard lima-bean agar;* I, *pseudopionnot conidia from 9-days-old culture on hard lima-bean agar with 2 per cent glucose (the longest spo is typical);* J, *pseudopionnotal conidia from 120-days-old culture on potato stem plug;* K, *sp rodochial conidia from 48-days-old culture on red raspberry cane plug*

Hab. On rotted tubers of *Solanum tuberosum*, Atlanta, New York.

Differs from *F. redolens* Wr. by somewhat narrower conidia and b color of substratum,[46] especially on potato agar rich in glucose.

Measurements of spores on different media are as follows:

[46] Wollenweber does not directly give color of substratum of his *F. redolens*, but judging from his definite negative statement in regard to *F. conglutinans* Wr. it appears evident that *F. redolens* does not differ noticeably in color from *F. oxysporum* and the majority of other species of the section Elegans.

On slightly acidified hard potato agar, culture fourteen days old; conidia from pseudopionnotes:

nidia: 2–septate, 0.5 per cent, 26 x 4.7μ
3–septate, 93.5 per cent, 36 x 5 (26–49 x 4.3–5.8)μ
4–septate, 6 per cent, 41.6 x 5.3 (38–46 x 4.9–6.1)μ
5– and 6–septate, rare, 43–53 x 5–6μ

On red raspberry cane plug, culture forty-eight days old; conidia from small sporodochium:

nidia: 0–septate, 2 per cent
1–septate, 1 per cent
3–septate, 97 per cent, 35.6 x 5 (28–45 x 4–5.9)μ

On hard lima-bean agar, culture nine days old; conidia from pseudopionnotes:

nidia: 0–septate, 17 per cent, 10 x 3.6 (6–16 x 3–4.3)μ
1–septate, 10 per cent, 20 x 3.9 (14–28 x 3.5–4.7)μ
2–septate, 3 per cent
3–septate, 70 per cent, 34 x 4.9 (28–43 x 4.3–5.3)μ
4–septate, rare

On potato tuber plug, culture ninety-nine days old; conidia from a medium small sporodochium:

nidia: 2–septate, rare, 27 x 4.8μ
3–septate, 100 per cent, 33.6 x 4.9 (29–39 x 4.6–5.7)μ

On potato stem plug, culture one hundred and thirteen days old:

(1) Chlamydospores, mostly unicellular

lamydospores: 0–septate, 6.5 x 6.1 (4.7–11 x 5.2–7.5)μ

(2) Conidia from a sporodochium

nidia: 0– and 1–septate, very rare
3–septate, 100 per cent, 34.5 x 4.5 (24–39 x 3.9–5.1)μ
4–septate, very rare, about the same size as 3–septate

On whole steamed potato tuber, culture forty-nine days old; conidia from a medium small sporodochium:

nidia: 0– and 1–septate, rare
3–septate, 100 per cent, 31 x 4.3 (29–36 x 4.1–4.8)μ

On rye grain, culture sixty-three days old; conidia from a si sporodochium:

(1) Conidia: 0–septate, 5 per cent
1–septate, 3 per cent
2–septate, 1 per cent
3–septate, 91 per cent, 34.6 x 4.6 (28–41 x 3.8–5.2)μ
4–septate, rare
5–septate, very rare

(2) Chlamydospores in mycelium, terminal, about the same size as th on potato stem plug

On corn agar, culture one hundred and seventy-three days old, chla dospores intercalary and terminal:

Chlamydospores: 0–septate (in conidia), 9.4 x 8.3 (7–11 x 5.2–9)μ
1–septate (in mycelium), 15 x 9 (11–20 x 7–11)μ

On hard lima-bean agar with 2 per cent glucose, culture one hund and eighteen days old:

(1) Chlamydospores not numerous; in conidia, 0–septate, 8.7 x 8.5μ mycelium, 0– and 1–septate, and also in small clusters of three

(2) Sporodochial conidia

Conidia: 1–septate, rare
3–septate, 94 per cent, 37 x 5 (28–44 x 4.6–5.9)μ
4–septate, 6 per cent, 40 x 5.05 (37–44 x 4.7–5.9)μ
5–septate, rare, about the same size as 4–septate

On hard lima-bean agar, culture five days old; chlamydospores conidia) not observed; conidia from pseudopionnotes:

Conidia: 0–septate, 10 per cent, 11 x 3.6μ
1–septate, 3 per cent, 22 x 4μ
2–septate, 1 per cent
3–septate, 86 per cent, 41 x 4.9 (33–53 x 4.6–5.2)μ
4–septate, rare
5–septate, very rare

On the same medium as above, culture thirteen days old; conidia fr pseudopionnotes:

Conidia: 0–septate, rare
3–septate, 97 per cent, 41 x 4.9 (34–49 x 4.2–5.2)μ
4–septate, 3 per cent, 43 x 5 (36–48 x 4.7–5.2)μ
5–septate, rare, 45 x 5.1 (43–47 x 4.8–5.2)μ

Average of the above measurements:
nidia: 0–septate, 3.5 per cent, 10.5 x 3.6μ
1–septate, 1.5 per cent, 21 x 3.95μ
2–septate, 0.5 per cent, 26.5 x 4.75μ
3–septate, 93 per cent, 36.4 x 4.86μ
4–septate, 1.5 per cent, 41.5 x 5.12μ
5–septate, rare, 44.3 x 5.2μ
6–septate, very rare

36. **Fusarium lutulatum** n. sp. (Figs. 1F1 and 32; Pl. II, figs. 5 and 6; V, fig. 3)

FIG. 32.— *Fusarium lutulatum.* A, *Conidia from plectenchymic sporodochium from 60-ays-old culture on red raspberry cane plug;* B, *pseudopionnotal conidia from 9-days-old culture n hard lima-bean agar with 2 per cent glucose;* C, *pseudopionnotal conidia from 5-days-old ulture on hard lima-bean agar;* D, *sporodochial conidia from 63-days-old culture on whole grain f rye;* E, *sporodochial conidia from 49-days-old culture on whole steamed potato tuber;* F, *pseudo-ionnotal conidia from 23-days-old culture on slightly acidified hard potato agar;* G, H, I, J, *onidiophores from 5-days-old culture on hard lima-bean agar;* K, *conidiophores from 23-days-ld culture on slightly acidified hard potato agar;* L, *terminal and intercalary chlamydospores rom 63-days-old culture on whole grain of rye;* M, *chlamydospores from 25-days-old culture n corn agar*

Macroconidia gradually attenuate toward the apex, usually distinctly pedicellate and uniformly curved throughout, without stronger curvature near apex, typically 3–septate, 34 x 4 (28–38 x 3.7–4.5)μ, also 2– to 5–septate; from small to medium sporodochia (up to 2 millimeters in diameter), often converging into pseudopionnotes; aërial mycelium, when present, short, (mostly from 1 to 2 millimeters high), white, often, especially on agars in plate cultures, absent; color of conidia from nearly white

(on aërial mycelium in the form of coarse powder) to dark vinaceo purple; typical variation of spore color shown in Plate II, figures 5 and sometimes on potato stem plug, from one to a few large sporodoch (2 millimeters in diameter) of a bright orange color produced; substratu from colorless to that of the conidial masses; small bluish black sclerot ($\frac{1}{2}$ millimeter in diameter) sometimes produced, and then in great nu bers all over the substratum (on potato tuber plug); zonation of colo very faint or none on neutral agars in plate cultures.

Hab. On soft and dry rotted tubers of *Solanum tuberosum*, Atlant New York.

Latin description.—Macroconidiis gradatim in apicem attenuatis, pl umque distincte pedicellatis et aequabiliter curvatis, non ad apice curvatioribus, typice 3–septatis, 34 x 4.23 (28–38 x 3.7–4.5)μ, vel etia 2–5–septatis; sporodochiis minutis vel mediocribus (usque ad 2 mm. diam saepe in pseudopionnotes vergentibus; aerio mycelio saepe — praecique agaribus in culturis in patellis factis — absente; conidiis ex albido (in aer mycelio similibus magnis granis pulveris) "dark vinaceous purple" (R vide typicam spororum coloris variationem, Tab. II, figg. 5, 6; interdu in tuberibus Solani tuberosi, vel unis vel paucis sporodochiis (2 mm. diam nitide "orange" (R); substrato hyalino vel eodem colore quo conidioru moles; interdum sclerotiis minutis livido-atris ($\frac{1}{2}$ mm. diam.), tum demu eorundem magnis numeris passim in substrato in tuberibus Solani tuberos zonatione coloniae vel maxime indistincta vel nulla in agaribus neutralibu in culturis in patellis factis.

Hab. In mollibus vel aridis putridis tuberibus Solani tuberosi, Atlanta New York, Amer. bor.

Measurements of spores on different media are as follows:

On slightly acidified hard potato agar, culture twenty-three days old conidia from pseudopionnotes:

Conidia: 0–septate, 4.5 per cent, 9 x 2.7 (6–14 x 2.5–3)μ
1–septate, 1 per cent, 18 x 3.2 (13–22 x 2.6–4)μ
2–septate, 0.5 per cent, 19.5 x 3.2 (17–23 x 2.7–3.5)μ
3–septate, 89 per cent, 35.2 x 4.5 (23–38 x 3.5–4.7)μ
4–septate, 4.8 per cent, 37.8 x 4.6 (31–40 x 4.3–4.7)μ
5–septate, 0.2 per cent, 45 x 4.7 (38–50 x 4.7)μ

On red raspberry cane plug, culture sixty days old; conidia from a medium-sized sporodochium:

Conidia: 0–septate, 25 per cent
1–septate, 5 per cent
2–septate, 1 per cent
3–septate, 65 per cent, 38 x 4.2 (27–44 x 3.5–4.7)μ
4–septate, 4 per cent, 42 x 4.4 (36–49 x 3.7–4.7)μ
5–septate, rare, about the size of 4–septate conidia

On hard lima-bean agar, culture nine days old; conidia from aërial mycelium:

Conidia: 0–septate, 57 per cent, 8.5 x 2.8 (7–12 x 2.6–3.5)μ
1–septate, 16 per cent, 14.5 x 3.25 (11–21 x 2.9–3.8)μ
2–septate, 3.5 per cent
3–septate, 23 per cent, 28 x 3.9 (23–37 x 3.5–4.4)μ
4–septate, 0.5 per cent, 35 x 3.9 (30–37 x 3.5–4.4)μ

On same media, culture twenty-two days old; conidia from small sporodochia:

Conidia: 0–septate, 3 per cent
1–septate, 1 per cent
2–septate, rare
3–septate, 84 per cent, 36 x 4 (29–40 x 3.9–4.4)μ
4–septate, 10 per cent, 39 x 4.3 (33–42 x 3.9–4.7)μ
5–septate, 2 per cent, 41 x 4.2μ (only a few measured)

On hard potato agar, culture thirty-one days old:

(1) Conidia from pseudopionnotes

Conidia: 0–septate, 26 per cent, 7.4 x 2.7 (5.2–12 x 2.6–3.5)μ
1–septate, 4 per cent, 13 x 3.3μ (only three measured)
2–septate, rare, 20 x 3.7μ (only three measured)
3–septate, 54 per cent, 35 x 4.2 (20–41 x 3.4–4.8)μ
4–septate, 12 per cent, 40 x 4.4 (35–44 x 4–4.8)μ
5–septate, 4 per cent, 43 x 4.8 (41–46 x 4–4.8)μ

(2) Chlamydospores (abundant)
(a) Terminal, 0–septate, on mycelium, 8 x 6.6 (7–9 x 6–7)μ
(b) Intercalary, in mycelium
0–septate, 8.2 x 6.2 (6–9 x 4.5–8)μ
1–septate, 11 x 5.7μ (only a few measured)
(c) In conidia, 0–septate, 6.5 x 5.9μ

On potato tuber plug, culture ninety-nine days old:

(1) Conidia from a sporodochium

Conidia: 0–septate, 5 per cent, 6.2 x 2.4 (4.5–8 x 2–2.9)μ
1–septate, 1 per cent, 13 x 2.7μ (only a few measured)
2–septate, rare, 20 x 3.3μ (only a few measured)
3–septate, 92 per cent, 32 x 3.8 (20–38 x 3–4.2)μ
4–septate, rare, 37 x 4.1μ (only one measured)
5–septate, very rare, about the size of 4–septate

(2) Chlamydospores, numerous, mostly in conidia
0–septate, 6.8 x 5.1 (5.2–7.2 x 4.6–5.3)μ
1–septate, 9.6 x 5.1 (7.8–12.3 x 4.1–6)μ, the largest 8.8 x 6.1

On potato stem plug, culture one hundred and twelve days old:

(1) Conidia from a sporodochium

Conidia: 0–septate, 1 per cent
1–septate, rare
3–septate, 79 per cent, 36.4 x 4.1 (33–39 x 3.9–4.7)μ
4–septate, 13 per cent, 40 x 4.2 (36–42 x 3.9–4.4)μ
5–septate, 7 per cent, 40 x 4.3 (35–45 x 4–4.7)μ
6–septate, very rare, same size as 5–septate

(2) Chlamydospores, in conidia common, mostly 0–septate, 6.3 x 5.
(5.1–8 x 4.3–6)μ

On whole steamed potato tuber, culture forty-nine days old; conidi from a sporodochium:

Conidia: 0–septate, 4 per cent
3–septate, 86 per cent, 36 x 3.7 (22–44 x 2.9–4.1)μ
4–septate, 8 per cent, 38 x 4.1 (35–43 x 3.9–4.2)μ
5–septate, 2 per cent, 40 x 4.1 (37–44 x 4.1)μ

On rye grain, culture sixty-three days old; conidia from a small sporo dochium:

Conidia: 0–septate, 35 per cent
1–septate, 12 per cent
2–septate, 1 per cent
3–septate, 45 per cent, 34 x 4 (24–44 x 3.5–4.4)μ
4–septate, 5 per cent, 41 x 4.2 (36–47 x 4–4.7)μ
5–septate, 2 per cent, 45 x 4.3 (44–51 x 4–4.7)μ

On corn agar, culture one hundred and seventy-two days old; most of the conidia with chlamydospores:

(1) Pseudopionnotal conidia (only those without chlamydospores were measured)

Conidia: 3–septate, 32 x 4μ
4–septate, 35 x 4.1μ
5–septate, 37 x 4.2μ

(2) Chlamydospores in conidia very numerous, 0–septate predominant, 7.3 x 6.8 (6–10 x 5–9)μ

On hard lima-bean agar with 2 per cent glucose, culture one hundred and eighteen days old:

(1) Chlamydospores in conidia very numerous, 0–septate predominant, 7.2 x 5.7 (6–8 x 5.2–6)μ

(2) Sporodochial conidia

Conidia: 3–septate, 99 per cent, 33 x 4.2 (29–39 x 3.8–4.7)μ
4–septate, 1 per cent, 36 x 4.3 μ (only three measured)

On hard lima-bean agar, culture five days old; conidia from aërial mycelium (chlamydospores in conidia not observed):

Conidia: 0–septate, 46 per cent, about 11 x 2.6μ
1–septate, 4 per cent, about 16 x 3.1μ
2–septate, 1.5 per cent
3–septate, 48 per cent, 32 x 4 (23–41 x 3.5–4.3)μ
4–septate, 0.5 per cent, 35 x 4.1μ (only two measured)

On same medium as above, culture thirteen days old; conidia from aërial mycelium:

Conidia: 0–septate, 25 per cent
1–septate, 6 per cent
2–septate, 1 per cent
3–septate, 63 per cent, 35 x 4.2 (30–40 x 3.9–4.7)μ
4–septate, 5 per cent, 37.8 x 4.4 (33–41 x 4–4.7)μ

Average of the above measurements:

Conidia: 0–septate, 20 per cent 8.4 x 2.6μ
1–septate, 1.5 per cent, 15 x 3.2μ
2–septate, 3.5 per cent, 20 x 3.4μ
3–septate, 69 per cent, 33.9 x 4.07μ
4–septate, 5 per cent, 39.4 x 4.23μ
5–septate, 1 per cent, 41.1 x 4.32μ

37. *Fusarium lutulatum* var. **zonatum** n. var. (Pl. I, figs. 9 and 10; Pl. V, fig. 4)

Differs from *F. lutulatum* by slightly shorter and broader microconidia; usually by the absence of chlamydospores in conidia;[47] by conidia somewhat less pointed than those in *F. lutulatum*; by commoner production of aërial mycelium; and by more or less distinct zonation of colony growth on neutral agars. Spore color begins to develop earlier but usually does not reach the density of that of *F. lutulatum*. The organism does not produce rot of potato tubers, while *F. lutulatum*, at least in most of the inoculations made, is capable of causing such rot. No sclerotia observed.

Hab. On rotted tubers of *Solanum tuberosum* together with *F. oxysporum* var. *resupinatum* and *F. sanguineum*, at Ithaca, New York.

The size of the conidia is in many instances almost identical with that in *F. lutulatum*, and in general there is scarcely any very sharp distinction between the two organisms; but there are at least slight differences in many of the important characters, so that in general there can hardly be any serious doubt that these are two distinct, though closely related, organisms.

Average of the measurements of conidia on the same media, of the same age, and the same in other ways, as those of *F. lutulatum*, is as follows:

Conidia: 0–septate, 23 per cent, 9 x 2.8μ
1–septate, 5 per cent, 16 x 3.1μ
2–septate, 2 per cent, 22 x 3.5μ
3–septate, 69 per cent, 32.77 x 4.16μ
4–septate, 1 per cent, 39.4 x 4.4μ
5–septate, very rare, 39.3 x 4.6μ

38. **Fusarium sclerotioides** n. sp. (Figs. $1o_1$ and 33; Pl. I, figs. 11 and 12; Pl. V, fig. 1)

Microconidia gradually attenuate toward and more or less pointed at the apex, pedicellate, generally somewhat more distinctly curved near apex, and broader in the middle or in the upper third of their length, typically 3–septate, 34.7 x 4.4 (30–39.5 x 4.1–4.6)μ, also 2– to 5–septate, 4– and 5–septate being of more or less common occurrence; chlamydospores observed only in mycelium (intercalary and terminal), and not very

[47] These were observed in number only once, and then when the culture was very old and much contaminated with bacteria. It was observed generally that a bacterial contamination greatly stimulates production of chlamydospores.

mon nor numerous when compared with all the other species of sec-
n Elegans, usually only unicellular; aërial mycelium on hard agars
ariably well developed, of medium height (from 2 to 4 millimeters)
l density, very frequently forming macroscopically observable knots at
hyphal tips, finally, if the conditions are right, resulting in production
umerous small sporodochia; large (up to 12 millimeters in diameter),
ish black, shiny, more or less wrinkled, sclerotia are frequently pro-
ed on potato tuber plugs; the sclerotia in some cases overgrown with
ial mycelium, and then not so conspicuous; plectenchymic bodies
m 1 to 3 or more millimeters in diameter) wartlike in appearance,

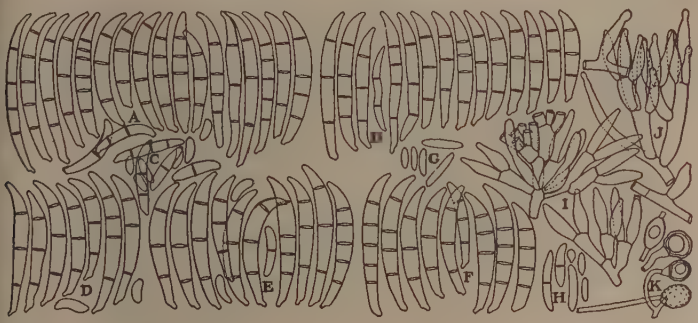


FIG. 33.— *Fusarium sclerotioides.* A, *Conidia from plectenchymic sporodochium from 14-s-old culture on potato tuber plug;* B, *conidia from plectenchymic sporodochium from 58-s-old culture on red raspberry cane plug;* C, *conidia from 24-days-old culture on slightly dified hard potato agar;* D, *sporodochial conidia from 6-days-old culture,* E, *sporodochial nidia from 12-days-old culture,* F, *sporodochial conidia from 51-days-old culture, on hard a-bean agar;* G, *microconidia from 13-days-old culture on hard lima-bean agar with 2 per t glucose;* H, *microconidia from aërial mycelium,* I, *sporodochial conidiophores, from 58-days-culture on red raspberry cane plug;* J, *conidiophore from 6-days-old culture on hard lima-n agar;* K, *chlamydospores from 58-days-old culture on red raspberry cane plug*

nite or pale flesh in color, often produced in considerable number and
some cases finally bearing masses of septate conidia; conidia, however,
rely produced on the sclerotia; color of the conidial mass somewhat
ariable, but usually of a tint of pinkish buff; color of substratum varying
om nearly colorless when young to cinnamon red, deep vinaceous, and
rk vinaceous purple. (For typical color when mature see Plate I,
gure 12.)

Hab. On rotted tubers and in discolored fibrovascular bundl tubers of *Solanum tuberosum* at Atlanta and Ithaca, New York, ar Louisiana.

Cultures of this organism on all media may for a long time pr microconidia almost exclusively; but if mature macroconidia fro casionally produced sporodochia are planted, macroconidia may be duced again in new cultures in great abundance and on almost any med

Latin description.—Microconidiis gradatim in apicem attenuatis, acutis, pedicellatis plerumque aliquatenus distinctius ad apicem cur medio latioribus vel superiore tertio longitudinis, typice 3–septatis, x 4.4 (30–39.5 x 4.1–4.6)μ, vel etiam 2–5–septatis, plus minusve 4–5–septatis; chlamydosporis tantum in mycelio (intercalaribus et minalibus) sed nec maxime frequentibus nec multis prae ceteris sect Elegantis speciebus, plerumque tantum unicellularibus; aerio mycel duris agaribus semper plene maturo, mediocriter alto (2–4 mm.) dens saepissime nodos nudo oculo conspicuos formante in hyphalibus apic demum — condicionibus faventibus — multa minuta sporodochia fer saepe sclerotiis magnis (usque ad 12 mm. diam.) livido–atris, lucidis, minusve rugosis, in tuberibus Solani tuberosi; sclerotiis — si aerio my obsita — minus conspicuis; saepe multis plectenchymicis corpor (1–3 mm. diam., vel majoribus), verrucoideis, albis vel pallide carneis moles septatorum conidiorum vel nullas tandem ferentibus; conidiis au in sclerotiis raro ortis; colore conidiorum molis aliquatenus variante, plerumque "pinkish buff" (R) tincto; colore substrati juvenis ferme hya dein "cinnamon rufous" (R), "deep vinaceous" (R), "dark vinaceous pur (R). (Vide typicam colorem maturi substrati Tab. 1, fig. 12.)

Hab. In putridis tuberibus et in decoloratis fibro-vascularibus fasci tuberum Solani tuberosi, Atlanta et Ithaca, New York, et Louisiana, Ar bor.

Measurements of conidia on different media are as follows:

On red raspberry cane plug, culture fifty-eight days old; conidia fro sporodochium:

Conidia: 1–septate, 1 per cent
2–septate, 1.5 per cent
3–septate, 87 per cent, 30 x 4.4 (21–40 x 3–5.1)μ
4–septate, 9 per cent, 37 x 4.5 (33–41 x 4.1–5.1)μ
5–septate, 1.5 per cent, 40 x 4.6 (35–45 x 4.3–5.1)μ

n hard lima-bean agar with 2 per cent glucose, culture thirteen days
conidia from aërial mycelium:
idia: 0–septate, 90 per cent, 9.5 x 2.25 (7–15.5 x 1.75–2.4)μ
1–septate, 10 per cent, 13.4 x 2.5 (12–18 x 2.3–3)μ

n corn meal agar, culture one hundred and seventy-three days old:
mydospores: 0–septate, in mycelium, 8.5 x 8.2 (7–11.5 x 5–10.5)μ

n hard lima-bean agar, culture six days old; conidia from a sporo-
ium:
idia: 0–septate, rare
1–septate, very rare
3–septate, up to 100 per cent, 37 x 4.3 (31–41 x 3.9–4.4)μ
4–septate, rare, 37 x 4.4μ (only one measured)

n same medium as above, culture fifty-one days old; conidia from a
dium-sized sporodochium:
idia: 0–septate, 1 per cent
1–septate, 1.5 per cent
3–septate, 73 per cent, 33 x 4.5 (23–39 x 3.5–4.8)μ
4–septate, 23 per cent, 37 x 4.5 (31–42 x 4–4.8)μ
5–septate, 1.5 per cent, 38 x 4.6 (31–42 x 4.2–4.9)μ

n same medium as above, culture twelve days old; conidia from
udopionnotes:
idia: 0–septate, 6 per cent
1–septate, 3 per cent
2–septate, exceptional
3–septate, 74 per cent, 35 x 4.6 [(22–) 33–39 x (3.5–) 4.1–4.8]μ
4–septate, 16 per cent, 36 x 4.7 (33–42 x 4.4–4.8)μ
5–septate, 1 per cent, 37 x 4.7 (35–40 x 4.6–4.8)μ

n potato tuber plug, culture fourteen days old; conidia from a medium-
d sporodochium:
idia: 0–septate, 8 per cent
1–septate, 3 per cent
2–septate, rare
3–septate, 46 per cent, 35 x 4.1 (29–43 x 3–4.7)μ
4–septate, 29 per cent, 40 x 4.2 (31–47 x 3.5–4.7)μ
5–septate, 14 per cent, 40 x 4.3 (35–47 x 4–4.7)μ

On hard oat agar, culture twenty-four days old; conidia from a spo dochium:

Conidia: 3–septate, 64 per cent, 39.5 x 4.3 (36–52 x 4–4.7)μ
4–septate, 28 per cent, 41 x 4.3 (38–45 x 4–4.7)μ
5–septate, 8 per cent, 43 x 4.5 (38–46 x 4.1–4.7)μ

Average of the above measurements:

Conidia: 0–septate, 16 per cent, 9.5 x 2.25μ
1–septate, 3 per cent, 13.4 x 2.5μ
2–septate, rare
3–septate, 63 per cent, 34.7 x 4.4μ
4–septate, 15 per cent, 37.9 x 4.43μ
5–septate, 3 per cent, 39.35 x 4.55μ

FIG. 34.—*Fusarium sclerotioides var. brevius.* A, *Pseudopionnotal conidia from 8-da old culture on hard lima-bean agar;* B, *sporodochial conidia,* C, *conidia from aërial myceliu from 19-days-old culture on slightly acidified hard potato agar;* D, *sporodochial conidia fr 45-days-old culture on red raspberry cane plug;* E, *conidia from aërial mycelium from 13-da old culture on hard lima-bean agar with 2 per cent glucose;* F, *sporodochial conidia,* G, *aër conidia, from 60-days-old culture on whole steamed potato tuber;* H, *sporodochial conidia fr 35-days-old culture on oats;* I, *chlamydospores from 45-days-old culture on red raspberry ca plug;* J, *chlamydospores from 25-days-old culture on corn agar;* K, L, *conidiophores from 1 days-old culture on slightly acidified hard potato agar;* M, *swollen tips of aërial hyphæ fro 13-days-old culture on hard lima-bean agar with 2 per cent glucose*

39. *Fusarium sclerotioides* var. **brevius** n. var. (Fig. 34; Pl. II, figs. and 2)

Differs from *F. sclerotioides* mainly by nearly constant absence of 4 and 5–septate conidia, by absence of large bluish black sclerotia, and b noticeably shorter, 3–septate conidia.

Hab. In discolored fibrovascular bundles of tubers of *Solanum tube rosum,* Alabama.

Measurements of the conidia on different media are as follows:

On red raspberry cane plug, culture forty-five days old; conidia from a plectenchymic sporodochium:

Conidia: 0–septate, 8 per cent, 15 x 3 (6–21 x 2.5–3.5)μ
1–septate, 17 per cent, 18 x 3.7 (17–23 x 3.5–4)μ
2–septate, 15 per cent, 20 x 4 (17–23 x 3.5–4.4)μ
3–septate, 60 per cent, 28.3 x 4.3 (19–39 x 3.5–4.8)μ
4–septate, rare

On slightly acidified hard potato agar, culture nineteen days old; conidia from a small sporodochium:

Conidia: 0–septate, rare
1–septate, rare
2–septate, 2 per cent, 24 x 4.2 (20–27 x 3.5–4.7)μ
3–septate, 98 per cent, 30.3 x 4.5 (21–37 x 4.1–4.8)μ

On hard lima-bean agar with 2 per cent glucose, culture thirteen days old; conidia from aërial mycelium:

Conidia: 0–septate, 98 per cent, 7.5 x 2.6 (4.3–18 x 2.3–3.7)μ
1–septate, 2 per cent, 13.5 x 3.2 (10–18 x 2.4–3.5)μ

On same medium as above, culture sixty-five days old; conidia from a sporodochium:

Conidia: 0–septate, 8 per cent, 6.4 x 2.8 (4.4–11 x 2.3–4.1)μ
1–septate, 5 per cent, 22 x 3.8 (15–29 x 3–4.3)μ
2–septate, 2 per cent, 24 x 4 (18–28 x 3.5–4.4)μ
3–septate, 85 per cent, 28 x 4.3 (24–35 x 3.7–4.8)μ

On corn meal agar, culture one hundred and seventy-three days old:

Chlamydospores: 0–septate, in conidia, 7.9 x 7 (5–11.5 x 5–9)μ
1–septate, in mycelium, 13.3 x 8.1 (11–18 x 7–9)μ

On hard lima-bean agar, culture eight days old; conidia from aërial mycelium:

Conidia: 0–septate, 55.5 per cent, 7.8 x 2.8 (5.2–13 x 2.1–3.9)μ
1–septate, 4 per cent, 13.3 x 3.2 (12–15 x 3–3.6)μ
2–septate, 0.5 per cent
3–septate, 40 per cent, 30.8 x 4.1 (23–37 x 3.9–4.2)μ

On same medium as above, culture twelve days old; conidia from pseudopionnotes:

Conidia: 0–septate, 12 per cent
1–septate, 3 per cent
2–septate, 2 per cent
3–septate, 83 per cent, 31 x 4.3 (22–41 x 4–4.7)μ
4–septate, exceptional, 41 x 4.4μ (only one measured)

On hard oat agar, culture twenty-four days old; conidia from a sporodochium:

3–septate, 100 per cent, 31.5 x 4.4 (23–35 x 3.8–4.7)μ

Average of the above measurements:

Conidia: 0–septate, 30.5 per cent, 9.2 x 2.8μ
1–septate, 5 per cent, 16.5 x 3.5μ
2–septate, 3.5 per cent, 22 x 4μ
3–septate, 61 per cent, 29.8 x 4.3μ
4–septate, very rare, 41 x 4.4μ

40. *Fusarium oxysporum* Schlecht.[48] (Figs. 1N$_1$ and 35A; Pl. v, fig. 6) Schlechtendal, Fl. Berol., 2:139. 1824. Smith, E. F., and Swingle, D. B., U. S. Plant Indus. Bur., Bul. 55. 1904. Wollenweber, H. W., Phytopath. 3:28, fig. 1F. 1913. Wollenweber, H. W., Journ. Agr. Research 2:268. 1914.

Microconidia gradually pointed toward apex, nearly cylindrical in middle half of their length, typically not broader toward apex, usually somewhat distinctly pedicellate, 3-septate dominant, 30.4 x 4.2 (27.5–34 x 4–4.4)μ,[49] in sporodochia and pseudopionnotes; 4–septate macroconidia frequently, and 5–septate ones rarely, present; in mass usually of pinkish buff color; aërial mycelium typically well developed, of medium height (from 3 to 5 millimeters) and density, from white to (in spots on boiled rice) congo pink;

[48] Original description of *F. oxysporum* Schlecht. (see von Schlechtendal, Flora Berolinensis 2:139) — "f. stroma convexum erumpens varium roseum superficie inaequali rugulosa, sporidiis parvis curvatis utrinque acutissimis"— is insufficient for identification of the species, and, short as it is, it sooner suggests some other species and not that of Smith and Swingle. For a detailed discussion of the matter see Appel and Wollenweber (1910: 144–146).

Wollenweber (1913 a: 28) gives his own description of *F. oxysporum* Schlecht., which, as he states (page 42 of reference cited), "includes some additions to the descriptions given by Smith and Swingle."

For the reason that, at least among pathologists and mycologists of the United States, this organism is fairly well known under this name, and after Wollenweber's description of it the meaning became definite and recognizable, the name *F. oxysporum* is retained here and is used for the organism described by Wollenweber without consideration of Schlechtendal's original description; that is, *F. oxysporum* here is as emended by Wollenweber.

[49] Wollenweber (1913 a: 28) gives the size variation as 25–45 x 3.25–4.5μ. Whether this is average or individual size variation is not stated.

substratum, on potato agar rich in glucose, vinaceous lilac, varying from colorless and orange vinaceous to pomegranate purple and vinaceous purple; plectenchymic sporodochia common on most of the media; bluish black sclerotia (up to 3 millimeters in diameter) constantly present on potato tuber plug and sometimes on different agars.

Hab. In fibrovascular bundles of diseased stems and tubers of *Solanum tuberosum*, in the United States, perhaps also in Europe, Africa, and other regions, also on *Lycopersicum esculentum* Vigna, and Pisum.

The organism was isolated alone and in association with several other Fusaria, several times from various localities in New York and in other States. The description given above is based on the study of the culture obtained through the courtesy of Dr. Wollenweber.

Measurements of the conidia are as follows:

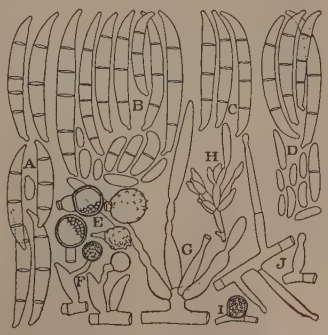


FIG. 35.— A, *Fusarium oxysporum, sporodochial conidia*
B–J, *F. oxysporum var. asclerotium:* B, *Conidia from 14-days-old culture on slightly acidified hard potato agar;* C, *conidia from 46-days-old culture on red raspberry cane plug;* D, *conidia from 7-days-old culture on hard lima-bean agar;* E, *chlamydospores from 46-days-old culture on red raspberry cane plug;* F, *terminal chlamydospores produced on normal conidiophores,* G *and* H, *conidiophores* (H *magnified 250 times*) *from 14-days-old culture on slightly acidified hard potato agar;* I, *chlamydospores from 25-days-old culture on corn agar;* J, *conidiophores from 7-days-old culture on hard lima-bean agar*

On slightly acidified hard potato agar, culture nineteen days old; conidia from aërial mycelium close to substratum:

Conidia: 0–septate, 87 per cent, 8 x 2.9 (4.5–12 x 2–4)μ
1–septate, 6 per cent, 16.5 x 3.4 (11–23 x 2.5–4.1)μ
2–septate, 1 per cent, 18.5 x 3.9 (17–26 x 3–4.2)μ
3–septate, 5 per cent, 27.5 x 4 (15–39 x 3–4.7)μ
4–septate, 1 per cent, about 40 x 4.5 (36–44 x 4.3–4.8)μ

On hard lima-bean agar, culture twelve days old; conidia from aërial mycelium:

Conidia: 0–septate, 99 per cent, 6.5 x 2.6 (4.5–16 x 1.75–3.5)μ
1–septate, 1 per cent, 14 x 3.2 (10–17 x 3–3.5)μ

On same medium as above, culture sixty-five days old:

(1) Conidia from a sporodochium

Conidia: 0–septate, 3 per cent
1–septate, 1 per cent
3–septate, 93 per cent, 33.8 x 4.3 (22–42 x 4–4.7)μ
4–septate, 3 per cent, 35.7 x 4.3 (33–41 x 4.1–4.7)μ
5–septate, rare, 35 x 4.4μ (only two measured)

(2) Chlamydospores, terminal and intercalary, 0–septate dominant

Chlamydospores: 0–septate, 8.7 x 8 (7–12.5 x 7–12.5)μ
1–septate, 15.5 x 9.2 (12–22 x 7.7–14)μ
Also in short chain, 2– and 3–septate, 2–septate commoner

On hard oat agar, culture twenty-three days old; conidia from a sporodochium:

Conidia: 3–septate, 93 per cent, 30 x 4.4 (26–35 x 3.9–4.7)μ
4–septate, 6 per cent, 34.5 x 4.5 (31–39 x 4.2–4.7)μ
5–septate, 1 per cent

On corn meal agar, culture one hundred and seventy-three days old; chlamydospores abundant, terminal and intercalary:

Chlamydospores: 0–septate, in conidia, 7.2 x 6.1 (6–9 x 4.8–8)μ
0–septate, in mycelium, 8.6 x 8 (7–10 x 7–11)μ
1–septate, often observed

On hard lima-bean agar, culture fifty days old; chlamydospores intercalary and terminal, in conidia and in mycelium, the latter most commonly observed:

Chlamydospores: 0–septate dominant, 8.9 x 7.3 (5.2–11 x 5.2–11)μ

Average of the above measurements of macroconidia:

Conidia: 3–septate, 0–93 per cent, 30.4 x 4.2μ
4–septate, 0–6 per cent, 36.7 x 4.43 (34.5–60 x 4.3–4.5)μ
5–septate, 0–rare, about 35 x 4.4μ

41. *Fusarium oxysporum* Schlecht. var. **asclerotium** n. var. (Fig. 35, B to J; Pl. v, fig. 7)

Differs from *F. oxysporum* mainly by absence of sclerotia and of definite plectenchymic sporodochia; differs also in color of mycelium and in somewhat longer and narrower macroconidia.

Hab. In rotted tuber of *Solanum tuberosum*, Atlanta, New York.

The organism was isolated from a flexible, semi-soft, rotted potato ber late in the spring. No other organisms were associated with it. ery similar organisms were isolated also from discolored fibrovascular ndles of potato tubers from various States.

Average measurements of the conidia from four different cultures are as llows:

onidia: 0–septate, 52.5 per cent, 7.9 x 2.6μ
1–septate, 8 per cent, 15 x 3.1μ
2–septate, rare
3–septate, 39 per cent, 34 x 4 (32–36 x 3.8–4.2)μ[50]
4–septate, 0.5 per cent, 37.5 x 4.35μ
5–septate, very rare, 37.5 x 4.35μ

Chlamydospores (on corn meal culture one hundred and seventy-three ays old):
0–septate, in conidia, 7.7 x 7 (6.5–11 x 5–8)μ
0–septate, in mycelium, 9 x 8 (7–11 x 5–8)μ
1–septate, in mycelium, 14 x 9.5 (11–16.5 x 7–13.4)μ[51]

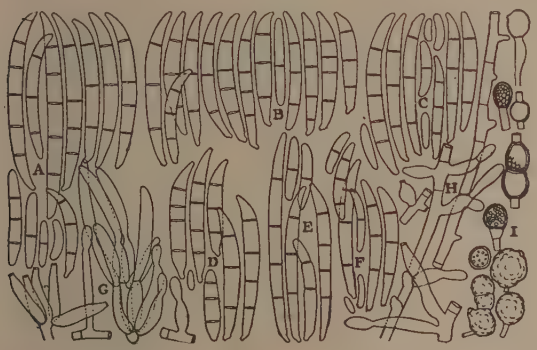


FIG. 36.— *Fusarium oxysporum var. longius.* A, *Pseudopionnotal conidia from 21-days-old lture on slightly acidified hard potato agar;* B, *conidia from 46-days-old culture on red rasp-rry cane plug;* C, *pseudopionnotal conidia from 5-days-old hard lima-bean agar;* D, *sporo-chial conidia from 36-days-old culture on oat agar;* E, *pseudopionnotal conidia from 22-days-d culture on corn agar;* F, *conidia from 202-days-old culture on potato stem plug;* G, *conidio-hores from 46-days-old culture on red raspberry cane plug;* H, *conidiophores from 5-days-old lture on hard lima-bean agar;* I, *chlamydospores from 202-days-old culture on potato stem ug*

[50] Variation of averages of at least ten spore measurements.
[51] Variation of individual spore measurements.

42. *Fusarium oxysporum* Schlecht. var. **longius** n. var. (Figs. 1M$_1$ and 36

Differs from *F. oxysporum* and other varieties of the species by longe macroconidia, typically 3–septate, 38.94 x 4.04 (34–45 x 3.6–4.4)μ, ofte 4– and 5–septate; no sclerotia; no macroscopical sporodochia.

Hab. In discolored fibrovascular bundles of tubers of *Solanum tube rosum* and of wilted stems, in New York, California, Maryland, an Connecticut.

On slightly acidified hard potato agar, culture twenty-one days old:

(1) Conidia from pseudopionnotes

Conidia: 0–septate, 1.5 per cent, 10 x 3 (8–12 x 2.5–3.5)μ
1–septate, 3 per cent, 18 x 3.5 (14–21 x 3–4)μ
2–septate, 0.5 per cent
3–septate, 60 per cent, 42.7 x 4.1 (28–54 x 3.5–4.8)μ
4–septate, 26 per cent, 49 x 4.3 (42–58 x 4–4.8)μ
5–septate, 9 per cent, 51.4 x 4.6 (46–60 x 4.3–4.7)μ

(2) Chlamydospores, terminal and intercalary

Chlamydospores: 0–septate, 7–9 x 5–6μ

On red raspberry cane plug, culture forty-six days old; conidia fro mycelium close to substratum:

Conidia: 0–septate, 1.7 per cent, 11 x 2.6μ
1–septate, 1 per cent, 19 x 3μ
2–septate, rare
3–septate, 93 per cent, 34 x 4.4 (19–44 x 3.5–5.7)μ
4–septate, 4.3 per cent, 40 x 4.6 (35–44 x 4.2–4.8)μ

On corn meal agar, culture twenty-two days old; conidia from surfac of medium:

Conidia: 0–septate, 20 per cent
1–septate, 8 per cent
2–septate, 2 per cent
3–septate, 40 per cent, 45 x 3.6 (36–54 x 3.2–4.2)μ
4–septate, 20 per cent
5–septate, 10 per cent
} the largest 67 x 4μ

On hard lima-bean agar with 2 per cent glucose, culture thirteen days old; conidia from aërial mycelium:

Conidia: 0–septate, 50 per cent, 8.6 x 2.5 (5.2–15 x 2.2–3)μ
1–septate, 10 per cent, 17.5 x 2.9 (12–21 x 2.3–3.5)μ
2–septate, 0.5 per cent, 21 x 3.2μ (only three measured)
3–septate, 30 per cent, 35.6 x 4 (24–50 x 3.2–4.4)μ
4–septate, 8 per cent, 45 x 4.2 (40–51 x 3.9–4.7)μ
5–septate, 1.5 per cent, 47.5 x 4.3 (42–51 x 3.9–5.1)μ

On hard lima-bean agar, culture five days old; conidia from aërial mycelium:

Conidia: 0–septate, 56 per cent, 11 x 2.4μ (only four measured)
1–septate, 4 per cent, 18 x 3.3μ (only four measured)
2–septate, 1.5 per cent
3–septate, 37 per cent, 37 x 4 (26–47 x 3.8–4.4)μ
4–septate, 1 per cent, 43 x 4.3 (40–45 x 4–4.5)μ
5–septate, 0.5 per cent, 50 x 4.4μ (only three measured)

On corn meal agar, culture one hundred and seventy-three days old:

Chlamydospores: (1) 0–septate, in conidia, 8.4 x 6.8 (7–9 x 5–8)μ
(2) 0–septate, terminal, on mycelium, 10 x 9 (9–10.5 x 7.5–10.5)μ

On potato stem plug, culture two hundred and two days old:

(1) Conidia from aërial mycelium close to substratum

Conidia: 0–septate, 40 per cent
1–septate, 20 per cent
2–septate, 10 per cent
3–septate, 30 per cent, 34.3 x 3.9 (22–42 x 3.4–4.1)μ.

(2) Chlamydospores, terminal and intercalary, in spores and mycelium

Chlamydospores: 0–septate, 8.9 x 6.8 (6.2–10 x 5.2–9)μ

On hard lima-bean agar, culture twelve days old; conidia from pseudopionnotes:

Conidia: 0–septate, 2 per cent
1–septate, 1 per cent
2–septate, rare
3–septate, 70 per cent, 44 x 4.3 (35–48 x 4–4.8)μ
4–septate, 23 per cent
5–septate, 4 per cent, 46 x 4.3 (40–53 x 4.1–5.2)μ

On hard oat agar, culture fourteen days old; conidia from pseudopion notes:

Conidia: 0–septate, 4 per cent, 10 x 2.5μ
1–septate, 1 per cent
2–septate, rare
3–septate, 70 per cent, 44 x 4.04 (39–50 x 3.5–4.7)μ
4–septate, 20 per cent, 45 x 4.2 (41–50 x 4–4.7)μ
5–septate, 5 per cent, 49 x 4.46 (42–51 x 4.3–4.7)μ

Average of the above measurements:

Conidia: 0–septate, 24 per cent, 10 x 2.6μ
1–septate, 7 per cent, 17.5 x 3.2μ
2–septate, 1 per cent, 21 x 3.2μ
3–septate, 52 per cent, 38.94 x 4.04μ
4–septate, 12 per cent, 44.25 x 4.35μ
5–septate, 4 per cent, 48.7 x 4.4μ

FIG. 37.—*Fusarium oxysporum var. resupinatum.* A, *Pseudopionnotal conidia from 15-days-old culture on slightly acidified hard potato agar;* B, *conidiophores from 6-days-old culture on hard lima-bean agar;* C, *conidiophore from 12-days-old culture on hard lima-bean agar;* D, *pseudopionnotal conidia from 6-days-old culture on hard lima-bean agar;* E, *conidiophores and chlamydospores,* F, *conidia, from 47-days-old culture on red raspberry cane plug*

43. *Fusarium oxysporum* Schlecht. var. **resupinatum** n. var. (Figs. 1L$_1$ and 37; Pl. I, figs. 7 and 8; Pl. V, fig. 5)

Differs from *F. oxysporum* by absence of sclerotia, from var. *asclerotium* and var. *longius* by shorter and somewhat narrower macroconidia. Mycelium on different agars typically entirely resupinate (Pl. I, figs. 7 and 8).

Hab. In discolored fibrovascular bundles of stem and tubers of *Solanum tuberosum*, United States.

This fungus and *F. oxysporum* var. *longius* are the organisms that were found very commonly present in discolored fibrovascular bundles of potato tubers and wilted plants. These organisms are also, as it seems, most commonly recognized by various pathologists as *F. oxysporum* Schlecht., as described by Smith and Swingle (1904); at least cultures of organisms undoubtedly belonging here were received under the name *F. oxysporum* from Mr. Wight in California, Dr. Taubenhaus in Delaware, and Dr. Clinton in Connecticut. The chief difference between these varieties of *F. oxysporum* of Smith and Swingle lies in the absence of sclerotia.

Measurements of spores on different media are as follows:

On slightly acidified hard potato agar, culture fifteen days old; conidia from thin pseudopionnotes:

Conidia: 0–septate, 74 per cent, 8 x 2.7 (5–15 x 2–4.3)μ
1–septate, 9 per cent, 21 x 3 (12–27 x 2.3–4.8)μ
2–septate, 4 per cent, 26 x 3 (20–37 x 2.2–4.1)μ
3–septate, 13 per cent, 35 x 4.2 (22–57 x 3.5–4.7)μ
4–septate, rare, 45 x 4.2μ

On red raspberry cane plug, culture forty-seven days old; conidia from aërial mycelium:

Conidia: 0–septate, 98 per cent, 6.5 x 2.7 (4.5–21 x 2.3–4.3)μ
1–septate, 2 per cent, 18 x 3.2 (12–24 x 2.8–4.1)μ
2–septate, rare, 22 x 3.4 (17–24 x 3–4.1)μ
3–septate, rare, 29 x 3.6 (19–36 x 3–4)μ

On hard lima-bean agar with 2 per cent glucose, culture fifteen days old; conidia from aërial mycelium:

Conidia: 0–septate, 97 per cent, 7.1 x 2.6 (5.2–16 x 1.8–4.3)μ
1–septate, 2 per cent, 16 x 3.1 (10–18 x 2.3–3.8)μ
2–septate, 0.5 per cent
3–septate, 0.5 per cent, 28 x 3.5 (23–36 x 2.4–4)μ

On corn meal agar, culture one hundred and seventy-three days old:

Chlamydospores: 0–septate, in conidia, 7.2 x 7 (5.8–9 x 5–8)μ
0–septate, in mycelium, 9.6 x 8.3 (7–16 x 7–11.5)μ
1–septate, in mycelium, 14.5 x 9.2 (13–18 x 7–11)μ

On hard lima-bean agar, culture six days old; conidia from pseudopionnotes:

Conidia: 0–septate, 82 per cent
1–septate, 5 per cent
2–septate, 2 per cent
3–septate, 11 per cent, 28 x 4.1 (22–36 x 3.9–4.7)μ

On the same medium as above, culture twelve days old; conidia also from pseudopionnotes;

Conidia: 0–septate, 15 per cent
1–septate, 8 per cent
3–septate, 77 per cent, 33.5 x 4.1 (29–37 x 4–4.5)μ; the smallest 21 x 3.4μ, the largest 40 x 4.5μ (both 3–septate)

Chlamydospores all kinds except terminal, 0–septate dominant, measuring 8.3 x 6.7 (6–10.5 x 5.2–8)μ

Average of the above measurements:

Conidia: 0–septate, 73 per cent, 7.2 x 2.7μ
1–septate, 5 per cent, 18 x 3.1μ
2–septate, 1.5 per cent, 24 x 3.2μ
3–septate, 20.5 per cent, 30.7 x 3.9μ
4–septate, rare, 45 x 4.2μ

X. SECTION DISCOLOR Wr., Phytopath. 3:31, fig. 1, G, H, J, 1913

Conidia sickle-shaped, at the middle nearly cylindrical or broadened toward the apex, somewhat abruptly apically attenuated, distinctly pedicellate; mostly 3– to 5–septate, 5–septate dominant; microconidia typically absent; chlamydospores intercalary only, usually scant; mycelium typically well developed, with from nearly white to orange color as type. Substratum from nearly colorless to chamois, pomegranate purple, and spectrum red. Color of conidia very variable, mostly cinnamon to orange.

Differs from sections Elegans and Martiella by absence of microconidia, by the conidia being typically somewhat abruptly attenuate, by absence of terminal chlamydospores, and by absence of vinaceous, drab-gray, tawny-olive, and blue color of substratum. By the shape of conidia this section occupies an intermediate position between sections Elegans and Martiella; by its color it is closely related to sections Roseum and Ferruginosum.

44. *Fusarium trichothecioides* Wr. (Figs. 1, U_1 and V_1, and 38; Pl. IV, fig. 8)

Jamieson, C. O., and Wollenweber, H. W., Journ. Washington Acad. Sci. 2:146–152, fig. 1. 1912.

Syn. *Fusarium tuberivorum* Wilcox and Link, Nebraska Agr. Exp. Sta., Research bul. 1:48. 1913.

Conidia of comma and discolor types the former predominating and under ordinary cultural conditions occurring almost exclusively, mostly 1–septate, 16 x 4.6 (14–17 x 4.2–5.4)μ, often 0– to 3–septate, seldom 4– or 5–septate, 6–septate rare; sporodochial conidia sickle-shaped, 3– to 5–septate, 24–42 x 4.5–5.5μ.[52] Typical conidiopho es of *comma* stage shown in figure 38. Sporodochial conidiophores similar to those of *F. discolor*. *F. trichothecioides* can be recognized at once by color and appearance of its powdery masses of spores produced on aërial mycelium (Pl. IV, fig. 8). Chlamydospores few and not prominent.

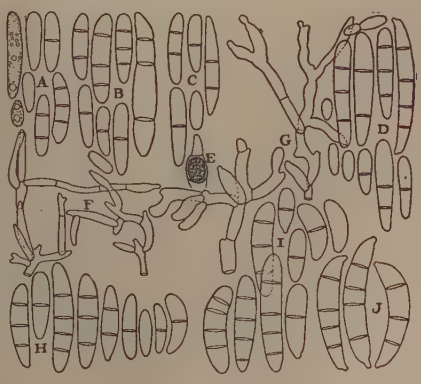


FIG. 38.—*Fusarium trichothecioides.* A, *Conidia from 41-days-old culture on rye straw;* B, *conidia from 70-days-old culture on potato stem plug;* C, *conidia from 73-days-old culture on red raspberry cane plug;* D, *conidia from 15-days-old culture on slightly acidified hard potato agar;* E, *chlamydospore in conidium from 73-days-old culture on red raspberry cane plug;* F, *conidiophores (magnified 250 times) from 70-days-old culture on potato stem plug;* G, *conidiophores from 15-days-old culture on slightly acidified hard potato agar;* H, *conidia from 5-days-old culture on hard lima-bean agar;* I, *comma,* J, *discolor, type of conidia from 5-days-old culture on potato tuber plug*

Hab. On rotted tubers of *Solanum tuberosum*, United States.

This species is noticeably different from all other species of the section Discolor. It is listed under this section chiefly because of its resemblance in the sporodochial form. Perhaps it should be made the type of a new section.

The organism, under the name *F. tuberivorum* Wilcox and Link, was

[52] The size of 3– to 5–septate conidia is as given by Wollenweber. The writer isolated this Fusarium from specimens of rotted potato tubers received from North Dakota in July, 1912, and from Texas in December, 1913. No special study of this organism was made at first, because it is easily recognizable even after a superficial examination, and also because its description as given by Wollenweber (see Jamieson and Wollenweber, 1912) is entirely sufficient for its identification.

extensively studied by Wilcox, Link, and Pool (1913). The identity of *F. tuberivorum* and *F. trichothecioides* Wr. is discussed by Wollenweber (1913 c:206). In the writer's opinion there is no doubt that this is correct.

The few measurements of the conidia on different media are as follows:

On slightly acidified hard potato agar, culture fifteen days old:

Conidia: 0-septate, 23 per cent, 8.2 x 3.8 (5–15 x 3–4.7)μ
1-septate, 59 per cent, 19 x 4.2 (12–26 x 3.5–4.7)μ
2-septate, 8 per cent, 22.4 x 4.3 (16–35 x 4.3–5.2)μ
3-septate, 10 per cent, 28.1 x 5 (20–39 x 4.3–5.3)μ
4- and 5-septate, few, 40–45 x 5μ

On red raspberry cane plug, culture seventy-three days old:

Conidia: 0-septate, 39 per cent, 12 x 4.2 (7–14 x 3–4.8)μ
1-septate, 50 per cent, 14 x 4.3 (14–20 x 3.9–4.8)μ
2-septate, 11 per cent, 22 x 4.5 (19–32 x 4.1–5.2)μ

On potato tuber plug, culture five days old, kept at a low (from 3° to 7° C.) temperature:

Conidia: 0-septate, 6 per cent, 14 x 5.2 (10–17 x 4.8–5.5)μ
1-septate, 53 per cent, 16 x 5.4 (12–23 x 4.4–7)μ
2-septate, 15 per cent
3-septate, 19 per cent, 26 x 5.8 (19–42 x 5.2–7)μ
4-septate, 6 per cent, 35 x 6.2 (33–40 x 5.4–7)μ
5-septate, 1 per cent, 38 x 6.3 (31–52 x 5.4–7)μ
6-septate, exceptional, 41 x 6.3 (39–47 x 6–7)μ (only three measured)

Average of the above measurements:

Conidia: 0-septate, 23 per cent, 11 x 4.4μ
1-septate, 54 per cent, 16 x 4.6μ
2-septate, 11 per cent, 21 x 4.8μ
3-septate, 10 per cent, 27 x 5.4μ
4-septate, 2 per cent
5-septate, rare, 38 x 6.3μ
6-septate, very rare

45. **Fusarium subpallidum** n. sp. (Fig. 39; Pl. v, fig. 12)

Conidia sickle-shaped, typically abruptly constricted at apex, slightly pedicellate to papillate, somewhat broader in the middle, mostly 5-septate.

29.1 x 5.53 (28–32.5 x 5.4–5.8)μ, 3– and 4–septate common, 6– and 7–septate very rare; chlamydospores common, mostly in long chains; aërial mycelium well developed; plectenchymic sporodochia (up to 3 millimeters in diameter) common; color of aërial mycelium from white to sea-foam yellow and honey yellow; color of substratum, on agars rich in glucose, mostly from chamois to raw sienna and antique brown in some old cultures; color of conidia, in mass, commonly from pinkish buff to pale orange, sometimes from green to blue.[53]

FIG. 39.— *Fusarium subpallidum.* A, *Sporodochial conidia from 70-days-old culture on hard potato agar;* B, *sporodochial conidia from 35-days-old culture on hard oat agar;* C, *conidia from a thin slimy layer from 15-days-old culture on slightly acidified hard potato agar;* D, *conidia from aërial mycelium from 52-days-old culture on red raspberry cane plug;* E, *conidiophores from 15-days-old culture on slightly acidified hard potato agar;* F, *chlamydospores from 175-days-old culture on corn agar;* G, *conidiophores from 52-days-old culture on red raspberry cane plug*

Hab. On superficial dry rot of tubers of *Solanum tuberosum.* The organism was isolated from rotted potato tubers received from Edgerton, Louisiana.

Latin description.—Conidiis falciformibus, typice subito apice constrictis, parum pedicellatis demum papillatis, medio aliquatenus latioribus, plerumque 5–septatis, 29.1 x 5.53 (28–32.5 x 5.4–5.8)μ, saepe etiam conidiis 3–4–septatis; conidiis 6–7–septatis rarissimis; chlamydosporis frequentibus plerumque longis catenulatis; aerio mycelio plene maturo; plectenchymicis sporodochiis (0–3 mm. diam.) frequentibus; aerio mycelio ex albo "sea-foam yellow" (R) vel "honey-yellow" (R); substrato, in agaribus perglucosis, plerumque e "chamois" (R) "raw sienna" (R) vel etiam in nonnullis culturis maturis "antique brown" (R); conidiis in totum plerumque e "pinkish buff" (R) pallide "orange" (R) vel interdum e viridi caeruleis.

[53] A very exceptional color for an organism of the section Discolor, and observed only in *F. subpallidum.* When the conidia are from green to blue in mass, some of them appear under the microscope very densely blue as if stained with methyl blue. The same was observed also in the case of *F. coeruleum*, *F. Martii*, and *F. Solani* var. *cyanum.*

Hab. In tuberibus aridis et extra putridis Solani tuberosi. Fungus e tuberibus Solani tuberosi putridis ab Edgerton in Louisiana, Amer. bor. receptis, sejungebatur.

Measurements of conidia on various media are as follows:

On slightly acidified hard potato agar, culture fifteen days old; conidia from pseudopionnotes:

Conidia: 0–septate, rare
1–septate, rare
2–septate, rare
3–septate, 23 per cent, 24.4 x 5.2 (16–30 x 4.7–5.7)μ
4–septate, 31 per cent, 25.6 x 5.5 (19–32 x 5.2–5.9)μ
5–septate, 45 per cent, 28 x 5.7 (24–34 x 4.7–5.9)μ
6– and 7–septate, 1 per cent, 31 x 6.1 (26–35 x 5.7–6.4)μ

On red raspberry cane plug, culture fifty-nine days old; conidia from aërial mycelium:

Conidia: 3–septate, 40 per cent, 24 x 4.7 (20–28 x 4.3–5)μ
4–septate, 18 per cent
5–septate, 42 per cent, 28 x 5.2 (24–31 x 5–5.3)μ (only four measured)

On hard potato agar, culture one hundred and seventy-five days old:

(1) Conidia from a sporodochium

Conidia: 3–septate, 4 per cent, 26 x 5.3 (23–28 x 5.2–5.4)μ
4–septate, 1 per cent
5–septate, 95 per cent, 29 x 5.8 (26–33 x 5.2–6.1)μ

(2) Chlamydospores
0–septate, in conidia, 8 x 7.5 (7–9 x 6–9)μ
1–septate, in mycelium, 15.5 x 10.3 (10–18 x 8.7–13.2)μ, the largest observed being 21 x 14μ

On medium soft potato agar, culture fifty days old:

(1) Conidia from thin pseudopionnotes

Conidia: 3–septate, 28 per cent, 25 x 5.4 (26–29 x 4.8—5.9)μ
4–septate, 23 per cent, about the size of 5–septate
5–septate, 49 per cent, 28 x 5.6 (24–32 x 5.2–6.3)μ

(2) Chlamydospores
0– and 1–septate, in clusters and chains, 7–16μ in diameter

On hard oat agar, culture twenty-three days old; conidia from sporodochium:

Conidia: 5–septate, 100 per cent, 32.5 x 5.4 (24–35 x 5.2–5.7)μ

Average of the above measurements:

Conidia: 0– to 2–septate, rare
3–septate, 19 per cent, 24.5 x 5.2μ
4–septate, 15 per cent, 25.6 x 5.5μ
5–septate, 66 per cent, 29.1 x 5.53μ
6– and 7–septate, very rare, 31 x 6.1μ

46. *Fusarium subpallidum* var. **roseum** n. var. (Fig. 1, s_1 and T_1; Pl. IV, fig. 3)

Differs from *F. subpallidum* by lower septation of conidia, the majority being 3–septate, 25.25 x 4.9 (22.5–27 x 4.7–5)μ, and by a tint or shade of from Tyrian rose to pomegranate purple in substratum on agars rich in glucose.

Hab. On rotted tubers of *Solanum tuberosum*, Kentucky.

Measurements of conidia on different media are as follows:

On slightly acidified hard potato agar, culture fifteen days old; conidia from pseudopionnotes:

Conidia: 0–septate, few
1–septate, 1 per cent, 17.5 x 4.7 (10–18 x 4.7)μ
2–septate, 1 per cent
3–septate, 44 per cent, 24.5 x 4.8 (18–29 x 4.7–5.3)μ
4–septate, 35 per cent, 27 x 4.9 (24–30 x 4.7–5.3)μ
5–septate, 19 per cent, 29 x 5.3 (24–32 x 4.7–5.7)μ

On red raspberry cane plug, culture seventy-three days old; conidia from a sporodochium:

Conidia: 0–septate, exceptional
1–septate, 2–septate } 1 per cent { 12 x 4.1 (10–14 x 3.8–4.4)μ / 23 x 4.8μ (only a few measured)
3–septate, 34 per cent, 26 x 5 (21–28 x 4.7–5.3)μ
4–septate, 35 per cent, 28 x 5.3 (23–30 x 4.8–5.7)μ
5–septate, 30 per cent, 30 x 5.3 (24–33 x 5–5.7)μ

On hard lima-bean agar, culture thirty-two days old; conidia from a sporodochium:

Conidia: 1–septate, 16 per cent
2–septate, 7 per cent
3–septate, 77 per cent, 22.5 x 4.8 (18–25 x 4.7–5.3)μ
4–septate, few, 26 x 5.1 (25–30 x 4.7–5.3)μ

On hard oat agar, culture twenty-three days old; conidia from a sporodochium:

Conidia: 3–septate, 90 per cent, 27 x 4.7 (24–34 x 4.1–4.9)μ
4–septate, 9 per cent, 29 x 4.9 (24–34 x 4.1–5.2)μ
5–septate, 1 per cent, 33 x 4.9 (30–40 x 4.8–5.2)μ

Average of the above measurements:

Conidia: 0–septate, rare
1–septate, 4.5 per cent, 17.5 x 4.7μ
2–septate, 2 per cent
3–septate, 61 per cent, 25.25 x 4.9μ
4–septate, 20 per cent, 27.5 x 5.1μ
5–septate, 12.5 per cent, 29.5 x 5.3μ

47. **Fusarium clavatum** n. sp. (Figs. $1R_1$ and 40; Pl. III, figs. 11 and 12; Pl. VII, fig. 2)

Conidia sickle-shaped, typically distinctly broader in upper third of their length, somewhat suddenly constricted at the apex, slightly pedicellate, mostly 3- to 5–septate, 5-septate measuring 36.2 x 5.05 (32–46 x 4.8–5.2)μ; aërial mycelium of a medium development (2 to 4 millimeters high, more or less loose) to nearly absent, and then substratum covered with pseudopionnotes; chlamydospores scant, not in long chains; color of aërial mycelium and substratum from white to light pink and that shown on Plate III, figures 11 and 12; color of pseudopionnotes from pale pink to deep olive-buff and chocolate brown (Pl. III, fig. 11); color of sporodochia bright orange (Pl. VII, fig. 2).

Hab. On rotted tubers of *Solanum tuberosum*, together with *F. coeruleum*, Castile, New York.

Latin description.—Conidiis falciformibus, typice distincte latioribus in superiore tertio longitudinis, apice aliquatenus subito constrictis, parum pedicellatis, plerumque 3–5–septatis, 5–septatis, 36.2 x 5.05 (32–46 x 4.8–5.2)μ; aerio mycelio mediocriter maturo (2–4 mm. alt., plus minusve laxo)

vel ferme nullo, quae cum ita sint substrato pseudopionnotibus obsito; chlamydosporis paucis, non catenulatis; aerio mycelio substratoque ex albo pallide rubello vel eodem colore quod in Tab. III, figg. 11, 12, exhibente; pseudopionnotibus e pallide rubello "olive-buff" (R) et "chocolate brown" (R); sporodochiis nitide "orange" (R).

Hab. In tuberibus putridis Solani tuberosi una cum F. coeruleo, Castile, New York, Amer. bor.

Measurements of conidia on various media are as follows:

On red raspberry cane plug, culture ninety-two days old; conidia from pseudopionnotes:

Conidia: 3–septate, 5 per cent, 27 x 4.2 (20–35 x 4–4.7)μ
5–septate, 95 per cent, 35 x 4.8 (29–39 x 4.3–5.7)μ

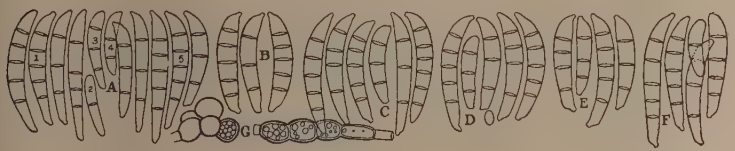


FIG. 40.— *Fusarium clavatum.* A, *Conidia from a thin layer near substratum from 92-days-old culture on red raspberry cane plug (conidia 1 and 5 are typical, but in certain areas conidia like 2, 3, and 4 were present almost to the exclusion of the other kinds);* B, *conidia from thin layer from 120-days-old culture on potato stem plug;* C, *pseudopionnotal conidia from 41-days-old culture on rye straw;* D, *pseudopionnotal conidia from 32-days-old culture on hard oat agar;* E, *pseudopionnotal conidia from 10-days-old culture on potato agar;* F, *pseudopionnotal conidia from 9-days-old culture on hard lima-bean agar;* G, *chlamydospores from 10-days-old culture on potato agar*

On hard lima-bean agar with 2 per cent glucose, culture twenty-two days old; conidia from aërial mycelium:

Conidia: 3–septate, 60 per cent, 26 x 4.9 (19–38 x 4.3–5.3)μ
4–septate, 16 per cent, 32 x 5.2μ (only one measured)
5–septate, 24 per cent, 32 x 5.15 (29–36 x 4.7–5.3)μ

On medium soft potato agar, culture ten days old; conidia from aërial mycelium (chlamydospores intercalary, in chains and clusters):

Conidia: 1–septate, 1 per cent, 16 x 4.4μ (only three measured)
3–septate, 82 per cent, 26 x 5 (23–31 x 4.7–5.4)μ
4–septate, 9 per cent, 29 x 5.1 (28–32 x 4.7–5.3)μ
5–septate, 8 per cent, 32 x 5.2 (29–34 x 4.7–5.3)μ

On hard lima-bean agar, culture nine days old; conidia from aërial mycelium close to substratum:

Conidia: 1–septate, very rare
2–septate, very rare
3–septate, 33 per cent, 30 x 4.6 (19–34 x 4.3–4.8)μ
4–septate, 23 per cent
5–septate, 44 per cent, 36 x 5 (33–40 x 4.6–5.4)μ

On same medium as above, culture fifteen days old; conidia from pseudopionnotes:

Conidia: 2–septate, very rare
3–septate, 36 per cent, 33 x 5 (22–39 x 4.6–5.3)μ
4–septate, 22 per cent
5–septate, 42 per cent, 36.5 x 5.1 (33–41 x 4.9–5.3)μ

Average of the above measurements:

Conidia: 1–septate, rare, 16 x 4.4μ
2–septate, very rare
3–septate, 43 per cent, 28.5 x 4.75μ
4–septate, 15 per cent
5–septate, 42 per cent, 36.2 x 5.05μ

48. *Fusarium discolor* Ap. et Wr. (Fig. 1_{Q1} and 41; Pl. IV, fig. 4; Pl. V, fig. 11)

Appel, O. and Wollenweber, H. W., Arb. K. biol. Anst. Land– u. Forstw. 8:108–115; Pl. I, figs. 50 to 59; Pl. III, fig. 7. 1910.

Conidia for greater part of their length of nearly even diameter, sickle-shaped, gradually attenuated, often somewhat suddenly constricted at the apex, pedicellate, mostly 3– to 5–septate, 5–septate measuring 38.7 x 5.1 (35–40 x 4.6–5.1)μ,[54] on aërial mycelium, in pseudopionnotes, and in plectenchymic sporodochia; chlamydospores scant, not in long chains; aërial mycelium from poorly to well developed, from pale pink-buff to ochraceous-orange and Eugenia red; color of substratum, on agars rich in glucose, from pale salmon at an early stage and warm sepia in old cultures to tyrian and ox blood; color of conidia mostly from light ochraceous salmon to ochraceous buff.

[54] Size of 5–septate conidia according to Wollenweber's data (see Appel and Wollenweber 1910 : 111-112) is 36 x 5.1 (29–39 x 4.5–5.5)μ. The writer's measurements were taken from cultures of the same organism. Average size of *F. discolor* strain isolated in United States is, for 3–septate conidia, 30.2 x 4.4μ (from 25 to 98 per cent), and for 5–septate conidia, 38.4 x 4.85 (33.5 41 x 4.5–5)μ (from 0 to 53 per cent).

Hab. In stems and rotten tubers of *Solanum tuberosum*, in Germany d in the United States.

Differs from *F. clavatum* mainly by indistinctly clavate conidia and by esence of denser hues of red color in substratum.

Measurements of conidia on various media are as follows:

On slightly acidified hard potato agar, culture twenty-four days old; nidia from pseudopionnotes:

nidia: 1–septate, rare
3–septate, 11 per cent, 32.3 x 4.3 (27–37 x 4.1–4.9)μ
4–septate, 14 per cent, 36 x 4.5 (32–42 x 4.3–5)μ
5–septate, 75 per cent, 39.2 x 4.7 (31–46 x 4.3–5.7)μ
6–septate, few, 53 x 5.8μ (only one measured)

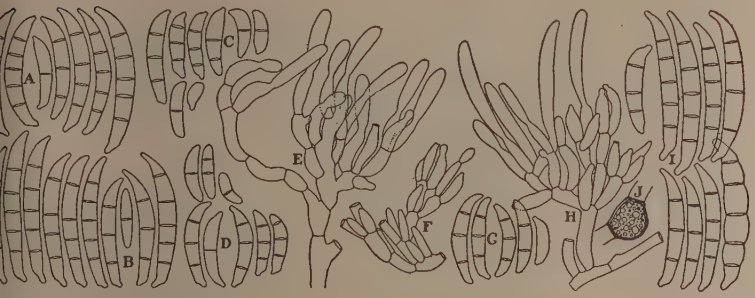


FIG. 41.—*Fusarium discolor.* A, *Conidia from a small plectenchymic sporodochium;* B, *idia from pseudopionnotes from 15-days-old culture on slightly acidified hard potato agar; conidia from 81-days-old culture on red raspberry cane plug;* D, *conidia from 36-days-old ure on potato stem plug;* E, *conidiophores from aërial mycelium from 81-days-old culture red raspberry cane plug;* F, *conidiophores from minute sporodochia from 36-days-old culture potato stem plug;* G, *conidia from mycelial growth from 41-days-old culture on rye straw; conidiophore from pseudopionnotes from 15-days-old culture on slightly acidified hard potato r;* I, *pseudopionnotal conidia from 9-days-old culture on hard lima-bean agar;* J, *intercalary amydospore from culture on corn agar*

On red raspberry cane plug, culture seventy-two days old; conidia from nute sporodochia on aërial mycelium:

nidia: 1– and 2–septate, rare
3–septate, 27 per cent, 30 x 4.4 (19–49 x 3.7–4.8)μ
4–septate, 24 per cent, 36 x 4.6 (26–49 x 3.9–5.9)μ
5–septate, 49 per cent, 40 x 5.2 (32–50 x 4.9–5.9)μ

On potato tuber plug, culture ninety-nine days old; conidia from sporodochium:

Conidia: 3–septate, 6 per cent, 26 x 4.7 (22–30 x 4.3–4.8)μ
4–septate, 25 per cent, 33 x 5 (28–40 x 4.6–5)μ
5–septate, 69 per cent, 35 x 5.2 (28–42 x 4.7–5.7)μ

On hard lima-bean agar with 2 per cent glucose, culture fifty-four days old; conidia from a small sporodochium:

Conidia: 1– to 3–septate, rare
4–septate, 2 per cent, 36 x 4.9μ (only two measured)
5–septate, 98 per cent, 40 x 5.2 (33–44 x 4.6–5.5)μ

On hard lima-bean agar, culture thirty-four days old; conidia from pseudopionnotes:

Conidia: 1–septate, very rare
3–septate, 49 per cent, 33.5 x 4.8 (24–44 x 4.1–6)μ
4–septate, 31 per cent
5–septate, 20 per cent, 39.3 x 5.1 (31–47 x 4.6–6.2)μ

Average of the above measurements:

Conidia: 1–septate, very rare
2–septate, very rare
3–septate, 19 per cent, 30.5 x 4.55μ
4–septate, 19 per cent
5–septate, 62 per cent, 38.7 x 5.1μ
6–septate, very rare, 53 x 5.8μ

49. *Fusarium discolor* Ap. et Wr. var. *sulphureum* (Schlecht.) Ap. et Wr. (Pl. IV, fig. 11)

Cf. Schlechtendal, Fl. Berol. **2**:134. 1824. Appel, O., and Wollenweber, H. W., Arb. K. biol. Anst. Land- u. Forstw. **8**:115–118. 1910.

Differs from *F. discolor* by absence of red color in mycelium and substratum, and by entirely exposed pseudopionnotes on various agars, a characteristic culture of which is shown in Plate IV, figure 11.

Average percentage of different septation types and sizes of conidia on three different media are as follows:

Conidia: 1–septate, about 0.5 per cent
2–septate, very rare
3–septate, about 25 per cent, 28.5 x 4.2μ

4–septate, about 28 per cent
5–septate, about 46.5 per cent, 40 x 4.9 (38–41 x 4.8–4.9)μ
6–septate, rare, 48 x 5.2μ

50. *Fusarium discolor* Ap. et Wr. var. **triseptatum** n. var. (Figs. 1W$_1$ and 42; Pl. IV, figs. 5 and 6; Pl. V, fig. 10)

Differs from *F. discolor* by dominance of 3–septate conidia 24.2 x 4.7 (22–26 x 4.5–4.9)μ, by presence of very large (up to 1.2 centimeters in diameter), warty, plectenchymic bodies (producing conidia or remaining sterile) of a pale pinkish buff with spots of a darker color, by more intense color of mycelium and substratum (see Plate IV, figures 5 and 6), and by production of larger sporodochia with darker spore masses, much the same as shown for *F. culmorum* var. *leteius* in Plate IV, figure 10.

Hab. On rotted tubers of *Solanum tuberosum* together with *F. coeruleum*, Long Island, New York.

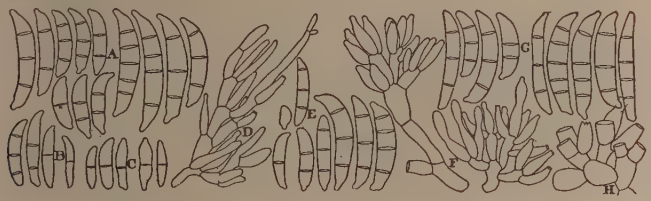


FIG. 42.— *Fusarium discolor var. triseptatum.* A, *Conidia from minute aërial sporodochia from 22-days-old culture on slightly acidified hard potato agar;* B, *conidia from 66-days-old culture on potato stem plug;* C, *conidia from aërial mycelium from culture on rye straw;* D, *conidiophore from aërial mycelium from 66-days-old culture on potato stem plug;* E, *conidia from plectenchymic sporodochia,* F, *conidiophores, from 22-days-old slightly acidified hard potato agar;* G, *conidia from plectenchymic sporodochia from 9-days-old culture on hard lima-bean agar;* H, *basal part of aërial compound conidiophore from 73-days-old culture on red raspberry cane plug*

Measurements of conidia on a few different media are as follows:

On slightly acidified hard potato agar, culture twenty-two days old; conidia from minute sporodochia on aërial mycelium:

Conidia: 0–septate, rare
1–septate, 1.6 per cent, 16 x 3.9μ
2–septate, 6.4 per cent, 18.5 x 4.3 (17–21 x 3.9–4.7)μ
3–septate, 91.2 per cent, 22.5 x 4.5 (17–39 x 3.9–5.7)μ
4–septate, 0.8 per cent
5–septate, very rare, 31 x 5.3 (28–35 x 5.2–5.8)μ

On red raspberry cane plug, culture seventy-three days old; conidia from a sporodochium:

Conidia: 0–septate, very rare
1–septate, 2 per cent, 15 x 3.7 (10–20 x 3–4.2)μ
2–septate, 8 per cent, 20 x 4.1 (17–23 x 3.6–4.7)μ
3–septate, 88 per cent, 24 x 4.6 (17–29 x 3.9–5.3)μ
4–septate, 2 per cent, 28 x 5.2 (25–30 x 4.8–5.7)μ

On hard lima-bean agar, culture nine days old; conidia from a young plectenchymic sporodochium:

Conidia: 1–septate, 2 per cent
2–septate, 3 per cent, 20 x 4.5 (13–25 x 4.1–4.7)μ
3–septate, 88 per cent, 26 x 4.9 (18–33 x 4.2–6)μ
4–septate, 6 per cent
5–septate, 1 per cent, 30 x 5.8μ (only a few measured)

Average of the above measurements:

Conidia: 0–septate, very rare
1–septate, 2 per cent, 15.5 x 3.8μ
2–septate, 6 per cent, 19.5 x 4.3μ
3–septate, 89 per cent, 24.2 x 4.7μ
4–septate, 3 per cent, 29.5 x 5.25μ
5–septate, few, 30.5 x 5.55μ

The organism seems to be so different from *F. discolor* that one may wonder why it is considered as a variety rather than an independent species, especially in view of the fact that there are some organisms designated as species which apparently differ very slightly from the other related species. The explanation lies mainly in the fact that, notwithstanding a seemingly great difference, this difference is in unstable characters — greater proportion of one type of septation instead of another, denser color, larger sporodochia, and so forth — and, moreover, in certain instances the two organisms approach each other so closely as to be distinguished only with considerable difficulty if at all.

51. *Fusarium culmorum* (W. Smith) Sacc. (Pl. IV, fig. 9; Pl. V, fig. 8)
Cf. Wollenweber, H. W., Journ. Agr. Research 2:260–261, Pl. XVI, fig. J. 1914.

Syn. *Fusarium culmorum* W. G. Smith, Dis. Field and Gard. Crops, pp. 208–210, fig. 92. 1884.
Fusarium Schribauxi Delacr., Bul. Soc. Mycol. France 6:99, pl. 15, fig. 1. 1890. Saccardo, Syll. Fung. 10:726. 1890.
Fusarium culmorum (W. Sm.) Sacc., Syll. Fung. 11:651. 1895.
Fusarium corallinum Mattirolo (non Sacc.), Mem. R. Accad. Sci. Ist. Bologna, ser. 5:6:677, figs. 16 and 17. 1897.
Fusarium rubiginosum Ap. et Wr., Arb. K. biol. Anst. Land- u. Forstw. 8:95–108; text fig. 8; Pl. 1, figs. 31 to 48. 1910.

Conidia for a greater part of their length of an even diameter, mostly 5–septate, 38.5 x 5.85 (37–40 x 5.3–6.2)μ, somewhat suddenly constricted at apex; pedicellate, of distinctly ochraceous orange color under microscope; chlamydospores of more or less common occurrence in mycelium and in conidia, not in long chains; aërial mycelium well developed, high (up to 1 centimeter and more), very loose, at first from white to pinkish cinnamon, and then to jasper and Eugenia red; substratum, on potato agar rich in glucose, of from spectrum red to carmine-pomegranate purple, with more or less brick red color; color of conidia in mass from cinnamon and light ochraceous to mikado brown and warm sepia; sporodochia minute, separate or converging into pseudopionnotes.

Hab. On cereals and on potato tubers and some other hosts, in Europe and the United States.

The organism was isolated by the writer from rotted potato tubers, alone and in association with other Fusaria.

Measurements of conidia on different media are as follows: [55]

On slightly acidified hard potato agar, culture twenty-three days old; conidia from pseudopionnotes:

Conidia: 3–septate, 5 per cent, 33 x 5.9 (21–36 x 4.7–6.1)μ
4–septate, 10 per cent, 35 x 6.1 (30–37 x 5.7–6.4)μ
5–septate, 85 per cent, 37 x 6.2 (32–46 x 5.2–6.5)μ

On red raspberry cane plug, culture seventy-two days old:

(1) Conidia from a sporodochium

Conidia: 3–septate, 3 per cent
4–septate, 10 per cent
5–septate, 87 per cent, 40 x 6.2 (33–53 x 5.8–7)μ

[55] Average of the measurements given by Appel and Wollenweber (1910:106) is as follows:
Conidia: 0– to 2–septate, about 1 per cent
3–septate, about 11 per cent, 26 x 5.5μ
4–septate, about 13 per cent, 27 x 5.7μ
5–septate, about 74 per cent, 39 x 6.1μ
6–septate, about 1 per cent, 45 x 6μ

(2) Conidia from aërial mycelium

Conidia: 3–septate, 60 per cent, 30 x 4.7 (19–39 x 4.1–5.9)μ
4–septate, 25 per cent, 37 x 5 (31–42 x 4.4–5.9)μ
5–septate, 15 per cent, 39 x 5.3 (35–43 x 5.2–5.9)μ

On hard lima-bean agar with 2 per cent glucose, culture one hundred and fifty-four days old; conidia from pseudopionnotes:

Conidia: 0–septate, rare, 8 x 4μ (only a few measured)
1–septate, rare, 12 x 3.7μ (only a few measured)
2–septate, rare
3–septate, 3 per cent, 26 x 4.7 (17–34 x 4.1–5.5)μ
4–septate, 7 per cent
5–septate, 89 per cent, 38 x 5.7 (33–47 x 5.2–6.1)μ
6–septate, 1 per cent, 49 x 5.7μ (only a few measured)
7–septate, very rare, 56 x 6.1μ (only a few measured)

Average of the above measurements:

Conidia: 0–septate, very rare, 8 x 4μ
1–septate, very rare, 12 x 37μ
2–septate, very rare
3–septate, 18 per cent, 29.67 x 5.1μ
4–septate, 13 per cent
5–septate, 69 per cent, 38.5 x 5.85μ
6–septate, few, 49 x 5.7μ
7–septate, exceptional, 56 x 6.1μ

52. *Fusarium culmorum* (W. Smith) Sacc. var. **leteius** n. var. (Figs. 1D$_2$ and 43; Pl. IV, figs. 1, 2, 10; Pl. V, fig. 9)

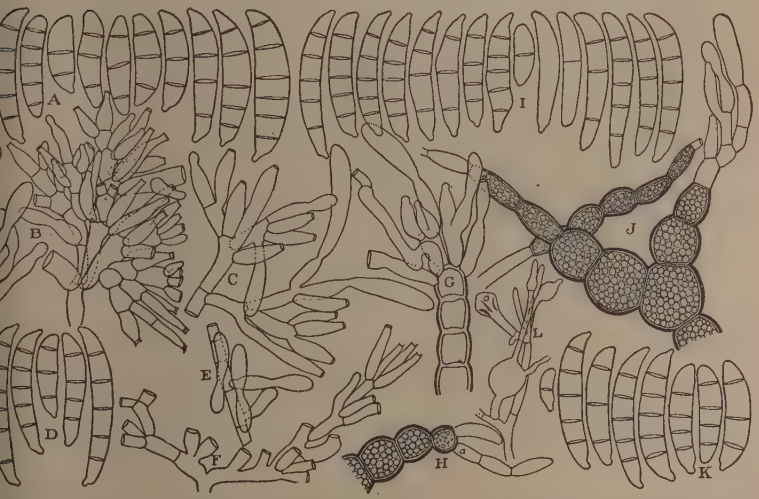
Differs from *F. culmorum* mainly by somewhat comma-like conidia from aërial mycelium, by typical presence of medium large (up to from 3 to 5 millimeters in diameter) sporodochia, and by somewhat broader average size of conidia.

Hab. On rotted tubers of *Solanum tuberosum*, Atlanta and Forks, New York.

Measurements of conidia on different media are as follows:

)n slightly acidified hard potato agar, culture fifteen days old; conidia
n a sporodochium:

iidia: 1–septate, 0.5 per cent, 18 x 5.2 (14–22 x 4.7–5.9)μ
2–septate, 5.5 per cent, 23 x 6.9 (20–26 x 6.4–7.9)μ
3–septate, 34 per cent, 26.5 x 7 (21–33 x 5.6–7.6)μ
4–septate, 38 per cent, 33.2 x 7.3 (26–38 x 6.4–7.9)μ
5–septate, 22 per cent, 36.4 x 7.5 (31–44 x 7–8.8)μ
6–septate, very few, 44.5 x 8.9μ (only one measured)



G. 43.— *Fusarium culmorum var. leteius.* A, *Conidia,* B, *conidiophores, from aërial sporo-ium from 15-days-old culture on slightly acidified hard potato agar;* C, *conidiophore from ays-old culture on hard lima-bean agar;* D, *conidia from plectenchymic sporodochium,* E, F, G, *liophores, from 72-days-old culture on red raspberry cane plug;* H, *intercalary chlamydospores 175-days-old culture on corn agar;* I, *conidia from plectenchymic sporodochium from 11-old culture on hard lima-bean agar;* J, *intercalary chlamydospores from 175-days-old culture rn agar (some chlamydospores producing conidiophores);* K, *conidia from aërial sporodochia 72-days-old culture on red raspberry cane plug;* L, *tip of aërial hypha showing prominent ings (magnification 250 times)*

)n red raspberry cane plug, culture seventy-two days old:

1) Conidia from a plectenchymic sporodochium borne directly on the plug

iidia: 3–septate, 14 per cent
4–septate, 20 per cent
5–septate, 66 per cent, 43 x 6.2 (31–53 x 5.8–7)μ

(2) Conidia from a bushlike sporodochium borne on aërial myceli
Conidia: 1– and 2–septate, very few
3–septate, 40 per cent, 29 x 6.9 (26–35 x 6–7.8)μ
4–septate, 30 per cent, 32 x 6.8 (29–36 x 6–7.5)μ
5–septate, 30 per cent, 37 x 6.8 (31–42 x 6.3–7.5)μ

On hard lima-bean agar, culture eleven days old; conidia from a spo
dochium (only mature spores measured):
Conidia: 1–septate, 2 per cent
3–septate, 26 per cent, 32 x 6.1 (24–37 x 5.2–6.7)μ
4–septate, 37 per cent
5–septate, 35 per cent, 39 x 5.9 (30–44 x 5.3–6.7)μ

Average of the above measurements:
Conidia: 1–septate, 0.5 per cent, 18 x 5.2μ
2–septate, 1.5 per cent, 23.5 x 6.9μ
3–septate, 28 per cent, 27.2 x 6.7μ
4–septate, 31 per cent
5–septate, 39 per cent, 38.85 x 6.6μ
6–septate, exceptional, 44.5 x 8.9μ (only one measured)

XI. Section Martiella Wr. (Fig. 1, x_1 to c_2). Wollenweber, H. W
Phytopath. 3:30, Fig. 1, A to C. 1913

Microconidia on aërial mycelium typically present, from oval to oblo
mostly 0–septate; macroconidia mostly 3–septate, of nearly even diam
throughout or but slightly broader either toward apex or toward b
nearly straight in lower half and more or less curved near apex, w
somewhat rounded apex or only slightly pointed or constricted, typic
from slightly pedicellate to apedicellate; aërial mycelium mostly fr
white to a light tint of chamois and drab hues; substratum, on neut
agars, never rose-pink nor pomegranate purple in color, sometir
from vinaceous to blue; color of conidia, except in acid media, mostly fr
pale buff to drab, often distinctly from green to blue.

53. *Fusarium Martii* Ap. et Wr. (Figs. 1, z_1 and A_2, and 44M)

Appel, O., and Wollenweber, H. W., Arb. K. biol. Anst. Land-
Forstw. 8:78–84, text fig. 5. 1910.

Macroconidia mostly 3–septate, 43.9 x 5.15 (42–46 x 4.9–5.3)μ, a

4–septate, 49.3 x 5.3 (48–50 x 4.9–5.4)μ, often also 5–septate, typically, when mature, of from deep lichen and montpellier green (on corn meal agar) to light olive-drab (on potato agar rich in glucose) and often to dark blue (on potato tuber plug);[56] macroconidia usually produced in abundance in small sporodochia and in pseudopionnotes; chlamydospores terminal and intercalary, single, in clusters, and in short chains, mostly 0–septate, 9.25 x 8.16 (8–11.3 x 7.5–9.3)μ; aërial mycelium typically medium short (from 1 to 4 millimeters), loose, more or less coarsely powdered with conidia, and typically, on potato agar rich in glucose, of from smoke gray to sometimes Chartura drab color; the substratum on the same kind of medium being mostly of from tawny olive to sepia in color.

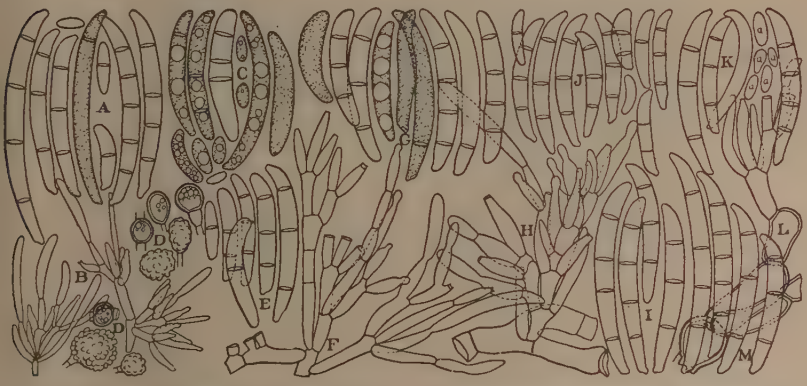


FIG. 44.— A-I, *Fusarium Martii var. viride.* A, *Pseudopionnotal conidia (the stippled one showing dense granulation of the protoplasm masking septation),* B, *conidiophores (magnification 250 times), from 11-days-old culture on slightly acidified hard potato agar;* C, *conidia showing dense granulation of the protoplasm containing from small to large oil globules from 29-days-old culture on rye straw;* D, *chlamydospores, terminal and intercalary,* E, *pseudopionnotal conidia, from 71-days-old culture on potato tuber plug;* F, *conidiophore from 70-days-old culture on potato stem plug;* G, *conidia,* H, *conidiophore, from 47-days-old culture on stem plug;* I, *pseudopionnotal conidia from 64-days-old culture on potato tuber plug*

J-L, *Fusarium Martii var. minus.* J, *conidia from plectenchymic sporodochium from 71-days-old culture on potato tuber plug;* K, *sporodochial conidia from 85-days-old culture on red raspberry cane plug;* Ka, *microconidia from aërial mycelium;* L, *basal part and one branch of compound conidiophore from 71-days-old culture on potato stem plug*

M, *Fusarium Martii, pseudopionnotal conidia from 11-days-old culture on slightly acidified hard potato agar*

[56] The culture media are mentioned here merely because the colors were oftener observed on these media than on others; in fact, a green color in conidia is often produced also on potato tuber plugs and on some other media, and the same is true of a blue color. The color is due to color of conidia, not to color of substratum alone, as can be observed under the microscope.

Hab. On rotted tubers of *Solanum tuberosum* and on other plants, in the United States and in Europe. The organism was isolated by the writer from specimens received from various States.

Measurements of conidia on different media are as follows:

On potato tuber plug, culture seventy days old; conidia from pseudopionnotes:

Conidia: 0–septate, rare
1–septate, 3 per cent
2–septate, rare
3–septate, 60 per cent, 46 x 5.3 (38–51 x 5.2–5.7)μ
4–septate, 30 per cent, 50 x 5.4 (43–54 x 5.2–5.9)μ
5–septate, 7 per cent, 52 x 5.6 (45–54 x 5.2–5.9)μ

On slightly acidified hard potato agar, culture eleven days old; conidia from thin pseudopionnotes:

Conidia: 0–septate, 2 per cent, 11 x 4μ
1–septate, 2 per cent, 20 x 4.5μ
2–septate, rare
3–septate, 23 per cent, 43.5 x 5.2 (33–51 x 4.6–5.3)μ
4–septate, 68 per cent, 49 x 5.6 (42–65 x 4.6–6.7)μ
5–septate, 5 per cent, 60 x 5.85 (56–63 x 5.6–6.45)μ

On red raspberry cane plug, culture eighty-two days old; conidia from a sporodochium:

Conidia: 1– and 2–septate, rare
3–septate, 57 per cent, 44 x 5.1 (29–50 x 4.3–5.9)μ
4–septate, 43 per cent, 51 x 5.3 (40–54 x 4.7–5.9)μ
5–septate, rare, 54 x 5.4μ (only one measured)

On potato tuber plug, culture sixty-four days old; conidia from thick pseudopionnotes:

Conidia: 0–septate, rare, about 9 x 3.5μ
3–septate, 55 per cent, 43 x 4.9 (28–50 x 4.7–5.1)μ
4–septate, 45 per cent, 48 x 4.9 (43–55 x 4.7–5.7)μ
5–septate, very rare

On hard lima-bean agar, culture sixty-eight days old; conidia from a small sporodochium:

Conidia: 0– to 2–septate, very rare
3–septate, 48 per cent, 42 x 5.2 (30–51 x 4.8–5.9)μ
4–septate, 50 per cent, 48 x 5.3 (41–53 x 4.8–5.9)μ
5–septate, 2 per cent, 51 x 5.5 (43–56 x 5–5.9)μ

On same medium and of same age as above, conidia from a medium large (about 2 millimeters in diameter), short, column-like sporodochium:

Conidia: 0– to 2–septate, very rare
3–septate, 49 per cent, 45 x 5.2 (36–49 x 4.5–5.6)μ
4–septate, 51 per cent, 50 x 5.2 (38–56 x 4.8–5.6)μ
5–septate, very rare

Average of the above measurements:

Conidia: 0–septate, rare, 11 x 4μ
1–septate, 1 per cent, 20 x 4.5μ
2–septate, very rare
3–septate, 53 per cent, 43.9 x 5.15μ
4–septate, 43 per cent, 49.3 x 5.3μ
5–septate, 3 per cent, 54.3 x 5.57μ

The average sizes given by Appel and Wollenweber for the same fungus are:

Conidia: 3–septate, about 44 per cent, 49 x 5.25μ
4–septate, about 51.5 per cent, 55 x 5.5μ
5–septate, about 4.5 per cent, 56.5 x 5.5μ

54. *Fusarium Martii* Ap. et Wr. var. **viride** n. var. (Fig. 44, A to I; Pl. VI, fig. 5)

Differs from *F. Martii* by having macroconidia somewhat narrower, and usually by a paler color of conidia and substratum; dark blue color of conidial masses not observed. Typical color of conidia in mass, on potato agar rich in glucose, pale smoke-gray, and of substratum pale drab-gray.

Hab. In discolored fibrovascular bundles of *Solanum tuberosum*, in stems and tubers, at Atlanta and Castile, New York.

Measurements of conidia on various media are as follows:

On potato tuber plug, culture seventy-one days old; conidia from pseudopionnotes:

Conidia: 0–septate, 4 per cent
1–septate, 22 per cent
2–septate, 10 per cent
3–septate, 60 per cent, 39 x 5 (33–43 x 4.6–5.2)μ
4–septate, 4 per cent

On slightly acidified hard potato agar, culture eight days old; conidia from pseudopionnotes:

Conidia: 0–septate, rare, 9 x 4μ
1–septate, rare, 17 x 5μ
2–septate, rare
3–septate, 41 per cent, about 46 x 5 (42–51 x 4.4–5.25)μ
4–septate, 58 per cent, 54.4 x 5.25 (45–68 x 4.8–5.6)μ
5–septate, 1 per cent, 58.5 x 5.7 (50–62 x 5–6)μ

On red raspberry cane plug, culture eighty-six days old; conidia from a sporodochium:

Conidia: 3–septate, 50 per cent, 45 x 5.2 (36–53 x 5–5.4)μ
4–septate, 50 per cent, 54 x 5.4 (42–61 x 5.2–5.9)μ

On hard lima-bean agar, culture twenty-two days old; conidia from pseudopionnotes:

Conidia: 3–septate, 90 per cent, 46.1 x 5 (40–49 x 4.7–5.3)μ
4–septate, 9 per cent
5–septate, 1 per cent

On potato tuber plug, culture sixty-four days old; conidia from thick pseudopionnotes:

Conidia: 3–septate, 55 per cent, 45 x 4.9 (40–49 x 4.8–5.3)μ
4–septate, 45 per cent, 49 x 5.3 (45–53 x 5–5.6)μ

On hard lima-bean agar, culture seventy-two days old; conidia from a columnar sporodochial mass:

Conidia: 3–septate, 73 per cent, 45 x 5.1 (40–49 x 4.7–5.3)μ
4–septate, 27 per cent, 50 x 5.2 (47–51 x 5–5.6)μ

Average of the above measurements:
Conidia: 0–septate, 0.5 per cent, 9 x 4μ
1–septate, 3 per cent, 17 x 5μ
2–septate, 1 per cent
3–septate, 63 per cent, 44.4 x 5.03μ
4–septate, 32 per cent, 51.9 x 5.27μ
5–septate, 0.5 per cent, 58.5 x 5.7μ

55. *Fusarium Martii* Ap. et Wr. var. **minus** n. var. (Fig. 44, J to L; Pl. 1, figs. 3 and 4; Pl. VI, fig. 6)

Differs from *F. Martii* and *F. Martii* var. *viride* by having smaller, 3–septate, conidia, 36.7 x 4.8 (30–44 x 4.55–5.1)μ, usually prominent development of plectenchymic, wartlike stromata, and fewer and larger sporodochia (Pl. VI, fig. 6).

Color of substratum, on potato agar rich in glucose, from light gray to drab and dark olive-buff, with a fuscous-colored spot at the point of inoculation (Pl. I, figs. 3 and 4).

Hab. On rotted tubers of *Solanum tuberosum*, evidently following *Phytophthora infestans*, Dutchess County, New York.

Measurements of conidia on different media are as follows:

On potato tuber plug, culture seventy-one days old:
(1) Conidia from a sporodochium
Conidia: 0–septate, 8 per cent
1–septate, 13 per cent
2–septate, 29 per cent
3–septate, 50 per cent, 30 x 4.6 (26–33 x 3.6–4.8)μ
(2) Conidia from pseudopionnotes
Conidia: 1–septate, 9 per cent
2–septate, 37 per cent
3–septate, 54 per cent, 30 x 4.55 (27–34 x 3.9–4.8)μ
(3) Conidia from oldest part of pseudopionnotes
Conidia: 3–septate, 100 per cent, 37 x 4.7 (27–43 x 4.2–5)μ

On slightly acidified hard potato agar, culture eleven days old; conidia from pseudopionnotes:
Conidia: 3–septate, 67 per cent, 43.75 x 4.6 (24–52 x 3.5–5.3)μ
4–septate, 28 per cent, 48.65 x 5 (43–53 x 4.3–5.3)μ
5–septate, 5 per cent, 52.85 x 5 (50–57 x 4.3–5.3)μ

On red raspberry cane plug, culture eighty-five days old; conidia from a sporodochium:

Conidia: 0–septate, rare
1–septate, rare
2–septate, rare
3–septate, 80 per cent, 38 x 5.1 (28–48 x 4.1–5.3)μ
4–septate, 20 per cent, 47 x 5.2 (42–52 x 4.9–5.5)μ
5–septate, rare, 47 x 5.2μ (only one measured)

On hard lima-bean agar with 2 per cent glucose, culture twenty-two days old:

Conidia: 3–septate, 88 per cent, 41.4 x 4.7 (36–47 x 4.1–5.3)μ
4–septate, 10 per cent
5–septate, 2 per cent

On potato tuber plug, culture sixty-four days old; conidia from pseudopionnotes:

Conidia: 0–septate, very rare
3–septate, 86 per cent, 40 x 4.8 (33–49 x 4.1–5.2)μ
4–septate, 14 per cent, 48 x 4.9 (38–56 x 4.7–5.7)μ

On hard lima-bean agar with 2 per cent glucose, culture sixty-eight days old; conidia from a columnar mass:

Conidia: 0– to 2–septate, very rare
3–septate, 93 per cent, 40 x 5.1 (30–45 x 4.7–5.4)μ
4–septate, 7 per cent, 44 x 5.1 (36–48 x 4.7–5.4)μ
5–septate, very rare, 47 x 5.3μ (only one measured)

On same medium, culture also same age; conidia from pseudopionnotes:

Conidia: 0– to 2–septate, very rare
3–septate, 98 per cent, 41 x 5 (33–42 x 4.7–5.3)μ
4–septate, 2 per cent, 44 x 5.1 (40–50 x 4.8–5.3)μ

Average of the above measurements:

Conidia: 0–septate, 11 per cent
1–septate, 2 per cent
2–septate, 6.6 per cent
3–septate, 71.6 per cent, 36.7 x 4.8μ
4–septate, 8.1 per cent, 46.2 x 5.06μ
5–septate, 0.7 per cent, 50 x 5.17μ

56. *Fusarium Solani* (Mart. p. par.) Ap. et Wr. (Fig. 1, X_1 and Y_1; Fig. 45, A to G; Pl. I, fig. 1; Pl. VI, fig. 7)

Appel, O., and Wollenweber, H. W., Arb. K. biol. Anst. Land- u. Forstw. 8:64–78; Pl. I, figs. 1 to 30; Pl. III, fig. 1; text fig. 4. 1910.

Microconidia always present, at least on aërial mycelium, same size and shape as those of *F. Martii*. Macroconidia typically somewhat broader

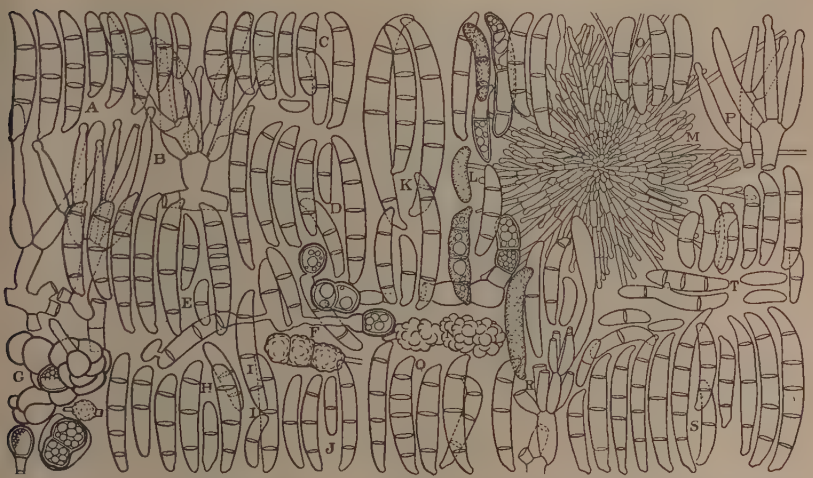


FIG. 45.— A-G, *Fusarium Solani*. A, *Conidia from plectenchymic sporodochia from 66-days-old culture on potato tuber plugs;* B, *conidiophores,* C, *conidia, from aërial mycelium from 12-days-old culture on hard lima-bean agar;* D, *pseudopionnotal conidia from 11-days-old culture on slightly acidified hard potato agar;* E, *conidia from sporodochium from 87-days-old culture on red raspberry cane plug;* F, *terminal, 1- to 3-septate, chlamydospores produced by hyphæ and conidia, the latter anastomosed, from 173-days-old culture on corn agar;* G, *terminal and intercalary, clustered, chlamydospores from 70-days-old culture on potato tuber plug*

H-J, *Fusarium Solani var. cyanum.* H, *Sporodochial conidia from 87-days-old culture on red raspberry cane plug;* I, *pseudopionnotal conidia from 15-days-old culture on slightly acidified hard potato agar;* J, *aërial conidia from 87-days-old culture on red raspberry cane plug*

K-T, *Fusarium Solani var. suffuscum.* K, *Pseudopionnotal conidia from 7-days-old colony in petri dish on hard potato agar (the middle spore above is typical for the culture);* L, *sporodochial conidia from 47-days-old culture on rye straw (many conidia have coarsely granulated protoplasm and oil globules);* M, *compound conidiophore in form of dense tuft (looking from above, magnification 250 times), from 47-days-old culture on potato stem plug;* N, *chlamydospores,* O, *sporodochial conidia, from 70-days-old culture on potato tuber plug;* P, *typical ends of conidiophores from 47-days-old culture on potato stem plug;* Q, *sporodochial conidia from 87-days-old culture on red raspberry cane plug;* R, *sporodochial conidia and conidiophore from 13-days-old culture on potato tuber plug;* S, *sporodochial conidia from 16-days-old culture on slightly acidified hard potato agar;* T, *sporodochial conidia from 47-days-old culture on potato stem plug*

in upper half of their length, with from rounded to slightly constricted apex, not at all or slightly pedicellate, typically 3–septate, 29.75 x 5.5 (27–34.7 x 5.4–5.8)μ, sometimes 4–septate, rarely 5–septate; aërial mycelium from poorly to well developed, from white to olive-buff; substratum, on potato agar rich in glucose, olive–buff with a green–blue tinge (Pl. I, fig, 1, and Pl. VI, fig. 7).

Hab. On *Solanum tuberosum* and other substrata, in Europe and America; often in association with other Fusaria.

The organism was often isolated by the writer from rotted potato tubers received from various States.

Measurements of conidia on various media are as follows:

On slightly acidified hard potato agar, culture eleven days old; conidia from pseudopionnotes:

Conidia: 1–septate, 0.5 per cent, 14 x 4 (13–17 x 3.5–5.8)μ
2–septate, 1 per cent, 22 x 4.5 (17–28 x 4.2–4.8)μ
3–septate, 93 per cent, 34.7 x 5.4 (22–42 x 4.3–6.1)μ
4–septate, 5 per cent, 38 x 5.8 (30–43 x 5–6.4)μ
5–septate, 0.5 per cent, 44.3 x 5.8 (38–47 x 5–6.4)μ

On potato tuber plug, culture sixty-five days old; conidia from a sporodochium:

Conidia: 0–septate, rare, 8.7 x 4μ (only a few measured)
1–septate, 2 per cent, 20 x 4.6μ
2–septate, 4 per cent, 23 x 4.7 (18–25 x 4.4–5.4)μ
3–septate, 93 per cent, 28 x 5.8 (22–35 x 4.8–6.1)μ
4–septate, 1 per cent, 33–5.9 (28–38.x 5.4–6.1)μ

On hard lima-bean agar, culture twelve days old:

(1) Conidia from aërial mycelium

Conidia: 0–septate, 20 per cent
1–septate, 40 per cent
2–septate, 19 per cent
3–septate, 21 per cent, 27 x 5.4 (24–37 x 4.7–6)μ

(2) Conidia from a sporodochium

Conidia: 0–septate, 1 per cent
1–septate, 1 per cent
2–septate, 1 per cent
3–septate (97 to 100 per cent), 29.3 x 5.4 (24–35 x 4.8–5.9)μ

Average of the above measurements:
Conidia: 0–septate, 5 per cent, 8.7 x 4μ
1–septate, 11 per cent, 17 x 4.3μ
2–septate, 6 per cent, 22.5 x 4.6μ
3–septate, 76.5 per cent, 29.75 x 5.5μ
4–septate, 1.5 per cent, 35.5 x 5.85μ
5–septate, rare, 44.3 x 5.8μ

57. *Fusarium Solani* (Mart. p. par.) Ap. et Wr. var. **cyanum** n. var. (Fig. 45, H to J)

Differs from *F. Solani* mainly by having macroconidia typically more rounded at apex and base, by fewer 4–septate and absence of 5–septate conidia, and by frequent occurrence of bluish plectenchyma (on hard bean agar and potato tuber plugs); sometimes distinct blue color in conidia also observable; size for the same septation type of conidia almost the same as that of *F. Solani*.

Hab. Same as for *F. Solani*, but much less common.

On potato tuber plug, culture sixty-eight days old; conidia from a sporodochium:
Conidia: 0–septate, 28 per cent
1–septate, 22 per cent
2–septate, 35 per cent
3–septate, 15 per cent, 28 x 5.2 (24–31 x 4.8–5.7)μ

On slightly acidified hard potato agar, culture fifteen days old; conidia from pseudopionnotes:
Conidia: 0–septate, 14 per cent, 12 x 3.7 (8.7–14 x 2.5–5)μ
1–septate, 22 per cent, 24.5 x 4.5 (15–30 x 3.5–5.3)μ
2–septate, 19 per cent, 29 x 5 (24–32 x 4.8–5.3)μ
3–septate, 45 per cent, 33 x 5.7 (31–35 x 5–6)μ

On red raspberry cane plug, culture eighty-seven days old; conidia from a sporodochium:
Conidia: 0–septate, few
1–septate, 3 per cent
2–septate, 5 per cent, 25 x 5.5 (19–27 x 4.7–5.8)μ
3–septate, 90 per cent, 30 x 5.7 (28–35 x 5.2–5.9)μ
4–septate, 2 per cent, 35 x 5.5 (33–37 x 5.2–5.7)μ

On potato tuber plug, culture sixty-five days old; conidia from a sporodochium:

Conidia: 0–septate, few
1–septate, 12 per cent, about 22 x 5μ (only one measured)
2–septate, 16 per cent, about 27 x 5.3μ (only one measured)
3–septate, 72 per cent, 29 x 5.6 (24–35 x 4.8–5.9)μ

On corn agar, culture one hundred and seventy-five days old; conidia only few, chlamydospores numerous, terminal and intercalary:

Chlamydospores: 0–septate, in mycelium, 11.3 x 9.3 (8.5–16 x 7.5–11)μ
1–septate, in mycelium, 16.3 x 9.9 (14–20 x 8–14)μ

On hard lima-bean agar, culture twelve days old; conidia from pseudopionnotes:

Conidia: 0–septate, 4 per cent
1–septate, 15 per cent
2–septate, 16 per cent
} (percentage may vary considerably from somewhat greater than figures given here to nearly zero)
3–septate, 65 per cent, 33 x 5.2 (27–37 x 4.7–5.6)μ

Average of the above measurements:

Conidia: 0–septate, 9 per cent, 12 x 3.7μ
1–septate, 15 per cent, 23 x 4.75μ
2–septate, 18 per cent, 27 x 5.3μ
3–septate, 57.5 per cent, 30.5 x 5.5μ
4–septate, 0.5 per cent, 35 x 5.5μ

58. *Fusarium Solani* (Mart. p. par.) Ap. et Wr. var. **suffuscum** n. var. (Fig. 45, K to T)

Differs from *F. Solani* and *F. Solani* var. *cyanum* mainly by typically well-developed, uniform, fine, aërial mycelium, with mass of chlamydospores at maturity which gives it a pale brownish tint; by sparse conidial production on aërial mycelium; and by the fact that sporodochia are usually few and distant from one another.

Hab. On rotted tubers of *Solanum tuberosum*, Wisconsin.

The average size and occurrence of septation type of conidia on various media are as follows:

Conidia: 0–septate, 5.5 per cent, 10.7 x 3.15μ
1–septate, 13.5 per cent, 20 x 4.5μ
2–septate, 17 per cent, 25 x 4.5μ
3–septate, 60.5 per cent, 30 x 5.41μ
4–septate, 3.5 per cent, 34.5 x 5.5μ
5–septate, rare, 42.25 x 5.85μ

59. **Fusarium striatum** n. sp. (Figs. 1C$_2$ and 46; Pl. I, fig. 2)

Microconidia, at least on aërial mycelium, always present. Macroconidia of shape and septation intermediate between *F. Martii* and *F. Solani*, mostly 3–septate, 34.7 x 4.6 (31–36 x 4.4–5)μ, from colorless to

FIG. 46.— *Fusarium striatum.* A, *Pseudopionnotal conidia from 17-days-old culture on slightly acidified hard potato agar;* B, *pseudopionnotal conidia from 58-days-old culture on oats;* C, *conidia from small sporodochium from 32-days-old culture on hard lima-bean agar;* D, *sporodochial conidia from 86-days-old culture on red raspberry cane plug;* E, *pseudopionnotal conidia from 13-days-old potato tuber plug (some of them anastomosing);* F, *pseudopionnotal conidia from 12-days-old culture on hard lima-bean agar;* G, *terminal chlamydospores produced by conidia from 64-days-old culture on hard lima-bean agar with 2 per cent glucose;* H, *chlamydospores from 32-days-old culture on hard lima-bean agar;* I, *compound conidiophore from 34-days-old culture on hard lima-bean agar*

yellowish glaucous and pale turquoise green, in numerous minute sporodochia; sporodochia often converging into a pseudopionnotes; aërial mycelium short (rarely up to 3 millimeters high), typically (on various agars) fine, uniformly from loose to very loose, downy in appearance, from white to grayish white; substratum, on agars rich in glucose, from pale glaucous green to tawny olive and sepia.

Hab. On tubers of *Solanum tuberosum*, Colorado.

Latin description.—Microconidiis—saltem in aerio mycelio—semper praesentibus; macroconidiis forma et septatione inter F. Martii et F.

Solani mediis, plerumque 3–septatis, 34.7 x 4.6 (31–36 x 4.4–5)μ, ex hyalino luteolo-glaucis vel pallide "turquoise green" (R), multis minutis sporodochiis; sporodochiis saepe in pseudopionnotem vergentibus; aerio mycelio brevi (usque ad 3 mm. alt.) typice (in agaribus variis) subtili, aequabiliter laxo vel laxissimo, pubescenti viso, ex albo caesio-albo; substrato — in agaribus perglucosis — ex pallide glauco-viridi "tawny-olive" (R) et "sepia" (R).

Hab. In tuberibus Solani tuberosi, Colorado, Amer. bor.

Measurements of conidia on different media are as follows:

On slightly acidified hard potato agar, culture seventeen days old; conidia from pseudopionnotes:

Conidia: 0–septate, 6 per cent, 10.6 x 3.15 (8.5–12.5 x 2.5–3.5)μ
1–septate, 10 per cent, 19.5 x 3.9 (14–21 x 3–4.4)μ
2–septate, 4 per cent, 24.15 x 4.2 (21–27 x 3.5–4.7)μ
3–septate, 64 per cent, 36.4 x 4.4 (26–50 x 4–5)μ
4–septate, 16 per cent, 47 x 4.5 (40–56 x 4.3–5.3)μ
5–septate, rare, 50 x 4.8 (47–56 x 4.3–5.3)μ

On red raspberry cane plug, culture eighty-six days old; conidia from a sporodochium:

Conidia: 0–septate, 3 per cent
1–septate, 7 per cent, 19 x 3.5 (12–23 x 3–4.1)μ
2–septate, 2 per cent
3–septate, 88 per cent, 41.6 x 5 (24–44 x 4–5.7)μ
4–septate, very rare, 43 x 5 (only one measured)

On hard lima-bean agar with 2 per cent glucose, culture sixty-four days old; conidia from pseudopionnotes:

Conidia: 0–septate, 10 per cent
1–septate, 22 per cent, 22 x 4.1 (16-30 x 3.5–4.7)μ
2–septate, 10 per cent
3–septate, 58 per cent, 31 x 4.6 (22–37 x 4.2–5)μ

On rye grain, culture sixty-four days old; conidia from a sporodochium:

Conidia: 0–septate, 39 per cent
1–septate, 28 per cent, 20 x 3.9 (14–23 x 3.5–4.4)μ
2–septate, 5 per cent
3–septate, 28 per cent, 31 x 4.6 (24–36 x 4.3–5)μ

On hard lima-bean agar, culture twelve days old:

(1) Conidia from a sporodochium
0–septate, 13 per cent
1–septate, 30 per cent
2–septate, 7 per cent
3–septate, 50 per cent, 33 x 4.4 (24–44 x 3.6–4.7)μ
4–septate, very few

(2) Chlamydospores, terminal and intercalary, mostly 0–septate, 9 x 7.5 (7–11 x 6–9)μ

On same medium as above, culture thirty-two days old; conidia from a sporodochium:

Conidia: 0–septate, 1 per cent, 9 x 3.6μ (only a few measured)
1–septate, 20 per cent, 20 x 3.9 (14–25 x 3.5–4.1)μ
2–septate, 5 per cent, 25 x 4.2 (23–30 x 4–4.4)μ
3–septate, 73 per cent, 35 x 4.6 (28–37 x 4–4.7)μ
4–septate, 1 per cent, 41 x 4.7μ (only a few measured)

Average of the above measurements:

Conidia: 0–septate, 12 per cent, 10 x 3.4μ
1–septate, 19.5 per cent, 20 x 3.9μ
2–septate, 5.5 per cent, 24.5 x 4.2μ
3–septate, 60 per cent, 34.7 x 4.6μ
4–septate, 3 per cent, 43.7 x 4.7μ
5–septate, very rare, 50 x 4.8μ

60. *Fusarium radicicola*[57] Wr. (Fig. 47; Pl. VI, fig. 8)

Wollenweber, H. W., Journ. Agr. Research 2:257-258, Pl. XVI, fig. K, 1914.

Microconidia nearly straight near base, slightly curved in upper third of their length, with from somewhat rounded to distinctly constricted apex, slightly pedicellate, mostly 3–septate, 35.2 x 4.7 (31–40 x 4.6–5)μ; 0– and 1–septate, microconidia very common, 0–septate measuring 8 x 3μ; chlamydospores common, terminal and intercalary, mostly 0– and 1–septate, 0–septate averaging 9–10 x 8.7–8.8μ; pseudopionnotes typically

[57] In an article which appeared after this work was ready for press, Dr. Wollenweber (1914) describes a new species of Fusarium (*F. radicicola*) with which this organism appears identical. No cultural comparisons have been possible, but the type of tuber rot and type of conidia are alike, and in certain instances material for study has come from the same region. Possibly any differences may be accounted for in the difference in strains studied.

absent; plectenchymic sporodochia often present; aërial mycelium well developed; color of conidia from white to olive, of substratum from pale yellowish to olive (on agar rich in glucose and on potato tuber plug).

Hab. On rotted tubers of *Solanum tuberosum*, in Oregon, Idaho, and California.

F. radicicola differs from *F. Martii* and *F. Martii* var. *viride* by shorter macroconidia; from *F. Martii* var. *minus* by absence of prominent plectenchymic sporodochia; and from *F. striatum* by well-developed aërial mycelium and by typical absence of pseudopionnotes.

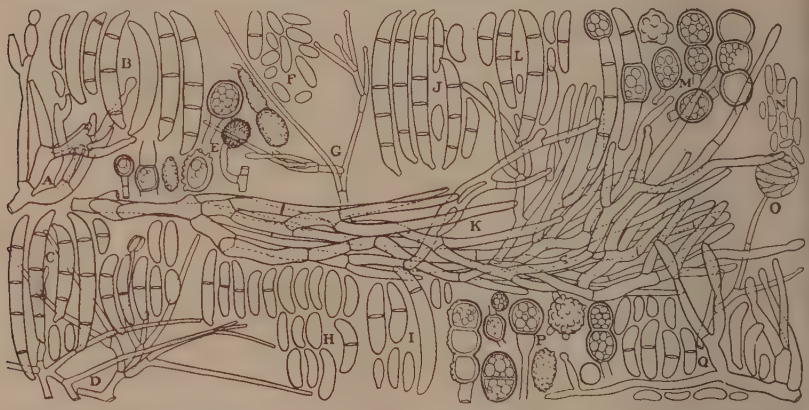


FIG. 47.— *Fusarium radicicola.* A, *Conidiophore,* B, *sporodochial conidia, from 67-days-old culture on potato stem plug;* C, *aërial and pseudopionnotal conidia from 12-days-old culture on hard lima-bean agar;* D, *conidiophore (magnification 250 times) from 48-days-old culture on rye straw;* E, *chlamydospores,* F, *aërial conidia,* G, *conidiophore (magnified 250 times), from 73-days-old culture on red raspberry cane plug;* H, *conidia from the surface of original stem-end rotted potato tuber;* I, *conidia from 48-days-old culture on rye straw;* J, *conidia from pseudopionnotes in 7-days-old colony in petri dish on hard potato agar;* K, *conidiophore from the surface of original stem-end rotted potato tuber;* L, *aërial conidia close to substratum from 64-days-old culture on hard lima-bean agar;* M, *chlamydospores produced in mycelium and conidia from 173-days-old culture on corn agar;* N, *conidia,* O, *spore ball, both magnified 250 times, from 3-days-old hanging drop culture in potato decoction in an Tieghem cell;* P, *chlamydospores from 82-days-old culture on potato tuber plug;* Q, *conidia and conidiophores from 26-days-old culture on oats*

Production of macroconidia in sporodochia was observed to be abundant only under certain conditions (not well determined as yet), but usually microconidia alone are the dominant type. The Oregon specimens, from which cultures of the fungus were first obtained, showed a

dark, depressed area of dry rot at the stem end of the tubers, with cream-white, dense tufts of conidiophores, up to 1 centimeter high and powdered with conidia. (For microscopic characters see figure 47.) Pure cultures of this organism were obtained both from the aërial conidia and from plantings of the rotted tissues of the tubers.

The organisms in general differ much from *F. striatum*, but in certain cultures (in sporodochia-producing stage on whole steamed potato tubers) resemble it very closely.

Measurements of conidia on different media are as follows:

On potato tuber plug, culture eighty-two days old:

(1) Conidia from aërial mycelium

Conidia: 0–septate, 95 per cent, 8 x 3 (6–15 x 2.1–4)μ
1–septate, 5 per cent, 15 x 4 (13–21 x 3.4–4.4)μ
3–septate, rare

(2) Chlamydospores, intercalary and terminal, unicellular and in chains
0–septate, 9.8 x 8.7 (5.2–16 x 5.2–12)μ

On hard lima-bean agar with 2 per cent glucose, culture sixty-four days old:

(1) Conidia from aërial mycelium close to substratum

Conidia: 0–septate, 80 per cent
1–septate, 17 per cent } (size same as above)
2–septate, 2 per cent
3–septate, 1 per cent, 33 x 4.8 (22–41 x 4.3–5.2)μ
4–septate, rare, 45 x 4.8 (only a few measured)

(2) Chlamydospores
0–septate, 9.5 x 8.8 (6.1–12 x 5.2–11)μ
1–septate, 18 x 10 (16–22 x 5–12)μ

On hard lima-bean agar, culture twelve days old:

(1) Conidia from aërial mycelium

Conidia: 0–septate, 60 per cent
1–septate, 30 per cent
2–septate, 1 per cent
3–septate, 6 per cent, 37 x 4.5 (28–48 x 4–5.3)μ
4–septate, 3 per cent, 43.6 x 5 (40–49 x 4.3–5.2)μ
5–septate, rare, size about that of 4–septate

(2) Chlamydospores, mostly 0–septate, 9 x 8.7μ

On whole steamed potato tuber, culture sixty days old; conidia from sporodochium:

Conidia: 0–septate, 11 per cent
1–septate, 21 per cent
2–septate, 8 per cent
3–septate, 60 per cent, 31 x 4.8 (29–38 x 4.2–5.5)μ
4–septate, very rare

On oat grain, culture fifty-seven days old; conidia from a sporodochium septation as above:

Conidia: 3–septate, 35.2 x 4.7 (25–42.5 x 4.2–5)μ
4–septate, 43 x 5μ (only one measured)

On potato stem plug, culture seventy days old; conidia from a sporodochium, septation approximately that given above:

Conidia: 3–septate, 35.2 x 5 (24.5–38 x 3.7–5.5)μ
4–septate, 41.6 x 5.8μ (only one measured)

On hard potato agar, culture ten days old; conidia from aërial mycelium close to substratum:

Conidia: 0–septate, 30 per cent
1–septate, 10 per cent
2–septate, 5 per cent
3–septate, 50 per cent, 40 x 4.6 (32–46 x 4.3–4.9)μ
4–septate, 5 per cent, 47 x 4.8 (45–49 x 4.5–5)μ

Average of the above measurements:

Conidia: 0–septate, 56 per cent (from 11 to 95 per cent), 8 x 3μ
1–septate, 16 per cent (from 5 to 30 per cent), 15 x 4μ
2–septate, 3 per cent (from 0 to 8 per cent)
3–septate, 23 per cent (from 0 to 60 per cent), 35.2 x 4.73μ
4–septate, 2 per cent (from 0 to 5 per cent), 43.9 x 5.1μ
5–septate, very rare, size about that of 4–septate

61. *Fusarium coeruleum* (Lib.) Sacc. (Figs. 1B$_2$ and 48; Pl. I, figs. 5 and 6; Pl. VI, fig. 4)

Syn. *Fusarium violaceum* Fuckel. 1869.
Selenosporium coeruleum Libert, in herbarium.

Cf. Saccardo, Syll. Fung. 4:705. 1886. Appel, O., and Wollenweber H. W., Arb. K. biol. Anst. Land- u. Forstw. 8:84–91, Pl. III fig. 6.

ext fig. 6. 1910. Wollenweber, H. W., Phytopath. 3:31, 44, 45, Fig. 1c. 1913.

Microconidia of larger size than those of other species of section Martiella, 0–septate, about 16 x 4.7μ. Macroconidia, for the largest part, of an even diameter or somewhat broader toward the base, only slightly curved near, and more or less rounded at, the apex, never apically constricted, mostly apedicellate or with ventrally depressed basal cell, mostly 3–septate, 33.3 x 5 (30–36 x 4.5–5.4)μ; aërial mycelium usually medium

FIG. 48.—*Fusarium coeruleum.* A, *Pseudopionnotal conidia,* B, *conidiophore, from 8-days-old colony in petri dish on hard potato agar;* C, *chlamydospores,* D, *coremium-like form of mycelial growth with conidiophores,* E, *pseudopionnotal conidia, from 35-days-old culture on potato tuber plug;* F, *conidiophore from 62-days-old culture on rye straw;* G, *conidia (some with chlamydospores),* H, *conidiophore (magnified 250 times), from 54-days-old culture on rye straw;* I, *conidia from small sporodochium,* J, *conidiophore, from 79-days-old culture on red raspberry cane plug;* K, *chlamydospores,* L, *pseudopionnotal conidia, from 22-days-old culture on hard potato agar.* A, B, F, G, *and* H *are from strains isolated from rotted potato tubers received from American sources, the remainder are from the culture received from Dr. Wollenweber*

well developed, feltlike in age, of from white, bluish white, and olive-buff to dusky slate violet, on potato agar rich in glucose, and to slate purple on corn meal agar; substratum, on potato agar rich in glucose, from deep hyssop violet to indian lake, ocher-red, and, in older cultures, violet-carmine; color of conidia from orchraceous orange, on strong acid agars, to pale buff and mouse gray, or often blue, on neutral media.

Hab. On rotted tubers of *Solanum tuberosum,* common in Europe and

America. Cause of most of Fusarial rot on potatoes in storage, often occurring in association with other Fusaria.

The organism was repeatedly isolated by the writer from diseased tubers, and every strain isolated proved capable of producing more or less dark-colored dry rot on tubers. It may be mentioned here that a white rot of tubers can be produced by certain species of Fusarium of the Elegans section, such as *F. lutulatum*. A rot distinctly striate in appearance was often produced by inoculation with *F. striatum*; a brownish rot of tubers is caused by *F. trichothecioides*; and a more or less pinkish rot with large cavities, more or less covered with red masses of macroconidia, is produced by *F. subulatum* and *F. subulatum* var. *brevius*.

Of all these, *F. coeruleum* is the commonest and most vigorous wound parasite of potato tubers; the next, perhaps, is *F. subulatum* and its variety.

Measurements of conidia of a few strains of the species on different media are as follows:

On slightly acidified hard potato agar, culture twenty-two days old; conidia from pseudopionnotes, strain 66:

Conidia: 0–septate, 5 per cent, 16 x 4.7 (6–28 x 4.3–5.5)μ
1–septate, 9 per cent, 21 x 4.7 (17–27 x 4.4–5.3)μ
2–septate, 10 per cent, 25 x 5.3 (18–32 x 4.6–5.9)μ
3–septate, 75 per cent, 30 x 5.4 (20–40 x 4.7–6.1)μ
4–septate, 1 per cent, 36 x 5.5 (33–40 x 5.2–6.1)μ

On red raspberry cane plug, culture seventy-nine days old; conidia from a sporodochium, strain 66; 3–septate, up to 100 per cent, 33 x 5.4 (22–40 x 4.8–6)μ; average septation being

Conidia: 0–septate, 3 per cent
1–septate, 11 per cent
2–septate, 8 per cent
3–septate, 78 per cent
4–septate, rare

On corn meal agar, culture one hundred and seventy-five days old; strain 53; very few conidia observed; chlamydospores numerous:

Chlamydospores: 0–septate, 8 x 7.5 (5.2–10.5 x 5.2–9)μ
1–septate, 11.7 x 7.7 (9.2–14 x 7–8.5)μ
Also in chains in mycelium, 9 (7.8–11)μ in diameter

On hard potato agar, culture one hundred and fifty days old; conidia from a sporodochium, strain 96:

Conidia: 0–septate, 10 per cent
1–septate, 12 per cent
2–septate, 7 per cent
3–septate, 71 per cent, 36 x 5.1 (33–40 x 4.4–5.5)μ

Chlamydospores: 0–septate, in conidia, average size 8.8 x 8μ

On potato tuber plug, culture eighty-five days old; conidia from a pseudopionnotes, strain 66:

Conidia: 0–septate, 5 per cent
1–septate, 8 per cent
2–septate, 4 per cent
3–septate, 68 per cent, 34.2 x 4.5μ
4–septate, 9 per cent, 42 x 4.6μ (only one measured)
5–septate, 6 per cent, 55 x 5.5μ (only two measured)

On rye straw, culture fifty-four days old; conidia from a sporodochium, strain 96:

Conidia: 0–septate, 2 per cent
1– to 2–septate, 5 per cent
3–septate, 89 per cent, 33.5 x 5.1 (30–37 x 4–6)μ
4–septate, 4 per cent, 33 x 6.1μ (only one measured)

On rye straw, culture fifty days old; conidia from a sporodochium, strain 66:

Conidia: 0– to 2–septate, 5 per cent
3–septate, 88 per cent, 30.5 x 4.9 (28–33 x 4.5–5.3)μ (only three measured)
4–septate, 7 per cent, 33.2 x 5.1μ (only one measured)

On rye straw, culture forty-three days old; conidia from a sporodochium, strain 53:

Conidia: 0– to 2–septate, 23 per cent
3–septate, 73 per cent, 35 x 5 (25–46.2 x 4.7–5.3)μ
4–septate, 4 per cent, 50 x 5μ (only one measured)

On potato hard agar, culture eight days old; strain 190:

Conidia: 0– to 2–septate, 2 per cent
3–septate, 80 per cent
4– and 5–septate, 10 per cent
6– and 7–septate, 8 per cent, 58 x 5.6 (57–60 x 5.2–6)μ

The greatest septation observed was in a culture fifteen days old on oat grains. This was a 9–septate conidium measuring 39 x 5.2μ.

Average of the above measurements:

Conidia: 0–septate, about 4 per cent, 16 x 4.7μ
1–septate, about 6 per cent, 21 x 4.7μ
2–septate, about 5 per cent, 25 x 5.3μ
3–septate, about 78 per cent, 33.3 x 5μ
4–septate, about 4.5 per cent, 39 x 5.26μ
5–septate, about 2 per cent, 55 x 5.5μ
6– and 7–septate, about 0.5 per cent, 58 x 5.6μ

Appel and Wollenweber's measurements for 3–septate conidia average 36 x 5.25 (31–40 x 4.5–5.5)μ

RAMULARIA (UNGER) Fries (Fig. 1, A to C)

Unger, F., Exantheme der Pflanzen, page 169. 1833. Fries, E. M., Summa vegetabilium Scandinaviae, page 493. 1849. Cf. Wollenweber, H. W., Phytopath. 3:33. 1913. Wollenweber, H. W., Phytopath. 3:207–211. 1913.

FIG. 49.—*Ramularia eudidyma.* A, *Conidia from aërial mycelium from 55-days-old culture on red raspberry cane plug;* B, *sporodochial conidia from 153-days-old culture on hard lima-bean agar;* C, *conidia from aërial mycelium from 25-days-old culture on slightly acidified hard potato agar*

Differs from Fusarium mainly by nearly cylindrical, apedicellate conidia, with rounded apex; plectenchymic stromata flat to well-developed, wartlike, short column-like structures typically present; conidia borne on conidiophores on aërial mycelium, or on plectenchymic substratum; microconidia (that is, a distinct, abbreviated type of conidia) absent.

1. *Ramularia eudidyma* Wr. (Figs. 1B and 49)

Wollenweber, H. W., Phytopath. 3:221–222, Pl. XXI, fig. C. 1913.

Syn. *Fusisporium didymum* Hartig. 1846.
Fusarium didymum (Hart.) Lindau. 1909.
Fusarium didymum (Hart.) Ap. et Wr. 1910.
Ramularia didyma (Hart.) Wr. 1913.

Conidia nearly cylindrical, with both ends rounded or basal ends sometimes papillate, mostly 1–septate, 23 x 4.87 (21–26 x 4.7–5)μ;[58] 0– to 2–septate conidia

[58] According to Wollenweber's data (1913 c: 234) the average size of 1–septate conidia is 26.4 x 5 (21–29 x 4.25–5.5)μ.

so found, 3–septate very rare; chlamydospores mostly intercalary, -11 μ in diameter; color of spore mass, from white to yellowish; color of ectenchyma, dense brown.

Hab. On decaying tubers of *Solanum tuberosum* and on roots of *Rubus æus*, also in soil, Europe.

The organism was not isolated by the writer, but was briefly studied om a culture received through the courtesy of Dr. Wollenweber.

2. *Ramularia Magnusiana* (Sacc.) Lindau (Figs. 1c and 50)

Cf. Wollenweber, H. W., Phytopath. 3:221, 234; Pls. xx, figs. F to H, id xxi, fig. A. 1913.

Conidia of the same type as those of *R. eudidyma*, also mostly 1–septate,

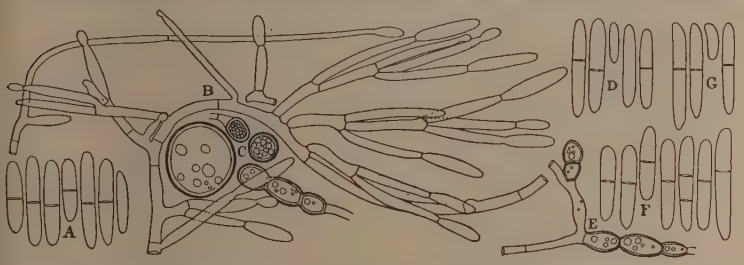


FIG. 50.— *Ramularia Magnusiana.* A, *Conidia from aërial mycelium,* B, *conidiophores, m 11-days-old culture in a petri dish on neutral hard potato agar;* C, *chlamydospores,* D, *sporo-chial conidia, from 51-days-old culture on red raspbery cane plug;* E, *chlamydospores from -days-old culture in a petri dish on neutral hard potato agar;* F, *conidia from aërial mycelium m 22-days-old culture on slightly acidified hard potato agar;* G, *sporodochial conidia from 3-days-old culture on hard lima-bean agar with 2 per cent glucose*

3.6 x 4.3 (18–27 x 3.5–5) μ;[59] 0– to 3–septate conidia also occurring, not umerous, sometimes catenulate; plectenchyma from olive to coffee brown. Much like *R. candida* (Ehr.) Wr., differing from it by old rose color on ce and by thinner conidia sometimes borne in chains. 0–septate chlamy-ospores 10 x 11 (7–11 x 9–16) μ; 1–, 2–, and pluri–septate chlamydospores so occurring.

Hab. Common on tubers of *Solanum tuberosum*, also found on the aves of Trientalis and on the roots of Acer, in Europe and America.

The fungus was isolated several times from rotted potato tubers, New ork, the tubers being covered with from a few to many, from dark brown

[59] The size is after Wollenweber (1913 c: 234).

to brick red, plectenchymic bodies, from 2 to 3 millimeters in diameter and from 1 to 4 millimeters high, often bearing characteristic, almost cylindrical, usually 1–septate, conidia.

The strains isolated by the writer differ from those described by Wollenweber, by more reddish color of plectenchyma, by somewhat narrower conidia and larger (?)[60] chlamydospores, and by the absence of persistent conidial chains.

Measurements of conidia of strain 63 on a few different media are as follows:

On slightly acidified hard potato agar, culture twenty-two days old; conidia from aërial mycelium:

Conidia: 0–septate, rare
1–septate, 95 per cent, 26.5 x 4.1 (18–30 x 3.5–4.7)μ
2–septate, 5 per cent, about the same size as 1–septate

On red raspberry cane plug, culture fifty-one days old; conidia from a sporodochium:

Conidia: 0–septate, 50 per cent, 13 x 3 (8–28 x 2.6–4)μ
1–septate, 50 per cent, 27 x 3.9 (24–31 x 3–4.3)μ

On hard lima-bean agar, culture one hundred and fifty-three days old; conidia from a sporodochium:

Conidia: 0–septate, 1 per cent, 10 x 3.4 (7.9–12.3 x 3–3.5)μ
1–septate, 99 per cent, 26 x 3.8 (20–32 x 3.5–4)μ

Average of the above measurements:

Conidia: 0–septate, 17 per cent, 11.5 x 3.9μ
1–septate, 81 per cent, 26.5 x 3.9μ
2–septate, 0 to 5 per cent, same as 1–septate

The average size of conidia according to Wollenweber's measurements is:

Conidia: 0–septate, rare, 14 x 3.8μ
1–septate, 100 per cent, 23.6 x 4.3μ
3–septate, rare, 30 x 5μ

It is possible that strain 63, on a thorough comparative study of it with *R. Magnusiana*, may prove to be a distinct variety; but it is evident that the resemblance between the two in all important characters is close enough to warrant its being placed in the species *R. Magnusiana*.

[60] Wollenweber does not give the size of chlamydospores, but it can be interpreted that it is the same as for *R. candida* (Ehr.) Wr., namely, 5–8μ in diameter. Chlamydospores of the strains described here on corn meal agar in cultures one hundred and seventy-three days old measured 10 x 11 (7–11 x 9–16)μ.

3. **Ramularia Solani** n. sp. (Figs. 1A and 51)

Conidia from nearly cylindrical to slightly curved, with both ends inded or with basal cell slightly papillate, mostly 1- and 2-septate; eptate measuring 29.5 x 6.5 (28–30 x 6.2–6.7)μ, and 2-septate meas- ng 32 x 6.4 (26–33.7 x 6.3–6.8)μ; plectenchyma flat, usually chocolate wn; aërial mycelium from 2 to 4 millimeters high, from medium dense medium loose, from chamois to deep olive-buff, on potato agar rich in cose, often with a chocolate-drab tinge; substratum, on the same dium, in zones of from sepia to tawny olive, and in old cultures to ecardo's amber; conidia in mass from nearly white to deep olive-buff; chlamydospores observed.

Hab. On rotted tubers of *Solanum tuberosum*, New York.

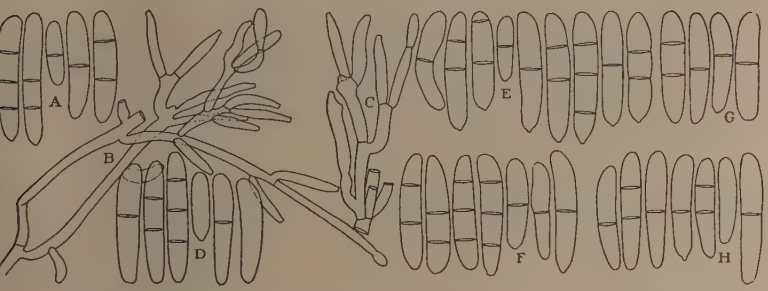


FIG. 51.— *Ramularia Solani.* A, *Sporodochial conidia from 12-days-old culture on oats;* nd C, *conidiophores from 34-days-old culture on hard lima-bean agar;* D, *conidia from aërial celium from 25-days-old culture on slightly acidified hard potato agar;* E, *conidia from aërial celium from 34-days-old culture on hard lima-bean agar;* F, *sporodochial conidia from 8- s-old culture on hard lima-bean agar;* G, *sporodochial conidia from 55-days-old red rasp- y cane plug;* H, *sporodochial conidia from 67-days-old flask culture on hard potato agar 2 per cent glucose*

Latin description.—Conidiis ferme cylindricis vel parum curvatis, risque finibus rotundatis vel cella infima parum papillata, plerumque 2-septatis; conidiis 1-septatis, 29.5 x 6.5 (28 30 x 6.2–6.7)μ, vel 2-sep- is, 32 x 6.4 (26–33.7 x 6.3–6.8)μ; plectenchymate plano, plerumque nocolate brown" (R); aerio mycelio 2–4 mm. alt., e mediocriter denso ediocriter laxo, e "chamois" (R) "olive-buff" (R), saepe in agare So- i tuberosi perglucoso "chocolate-drab" (R) tincto; substrato, eodem in are, e "sepia" (R) "tawny olive" (R) in zonis, vel in culturis maturis

"Saccardo's amber" (R); conidiis in totum e ferme albo olivaceo-gilvis nullis chlamydosporis.

Hab. In tuberibus putridis Solani tuberosi, New York, Amer. bor.

Measurements of conidia on different media are as follows:

On slightly acidified hard potato agar, culture twenty-five days old conidia from a sporodochium:

Conidia: 0–septate, rare
1–septate, 25 per cent, 28–35 x 5.5–6.3μ
2–septate, 45 per cent, 26 x 6.3 (29–39 x 6.7)μ
3–septate, 30 per cent, 37 x 6.5 (30–41 x 6.3–7)μ

On red raspberry cane plug, culture fifty-five days old; conidia from a sporodochium:

Conidia: 1–septate, 63 per cent, 30 x 6.7 (20–34 x 5.5–7.4)μ
2–septate, 37 per cent, 33 x 6.8 (25–37 x 6.5–7.4)μ

On the same medium as above, culture one hundred and thirty-six days old; conidia from a sporodochium:

Conidia: 0–septate, few, 19 x 5.4μ (only a few measured)
1–septate, 30 per cent, 28 x 6.2 (20–32 x 5.2–6.8)μ
2–septate, 62 per cent, 33 x 6.5 (28–40 x 6–7)μ
3–septate, 8 per cent, 35 x 6.5 (31–40 x 6–7)μ

On hard lima-bean agar, culture eight days old; conidia from a sporodochium:

Conidia: 1–septate, 44 per cent, 30 x 6.3 (22–35 x 5.5–6.5)μ
2–septate, 49 per cent, 33.7 x 6.4 (29–39 x 6–6.6)μ
3–septate, 7 per cent, 36 x 6.5 (31–40 x 6–6.6)μ

On same medium and from same sporodochium as above, culture thirty-four days old:

Conidia: 0–septate, rare
1–septate, 46 per cent, 30 x 6.2 (23–37 x 5.4–6.5)μ
2–septate, 35 per cent, 33.6 x 6.3 (24–39 x 5.8–6.5)μ
3–septate, 19 per cent, 36.9 x 6.5 (32–39 x 6.1–7)μ

Average of the above measurements:

Conidia: 0–septate, rare, 19 x 5.4μ
1–septate, 42 per cent, 29.5 x 6.5μ
2–septate, 45 per cent, 32 x 6.4μ
3–septate, 13 per cent, 36 x 6.5μ

This organism, together with *Fusarium udum* var. *Solani*, was isolated by the writer only once, from a planting of diseased tissues of a potato tuber affected with a superficial dry rot, received from Long Island, New York.

By the shape and size of its conidia it very closely resembles *R. macrospora* Fres. (see Wollenweber 1913 c:222-223, 235, Pl. XX, A and B, and Pl. XXI, E), but differs mainly by the absence of oval, continuous conidia on aërial mycelium, and by the absence of chlamydospores.[61]

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[61] Chlamydospores were searched for very carefully in cultures on different media and of different ages, very old cultures being included, but were never observed. According to Wollenweber (1913 c: 208) such organisms, Ramularia-like but without chlamydospores, produce perfect forms of the genus Mycosphærella; although the organism described here under the name of *R. Solani*, when grown on various media, did not produce chlamydospores, nevertheless it has been retained in this genus because of its otherwise perfect resemblance to the other unquestionable species of Ramularia.

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EXPLANATION OF PLATES

All the plates were reproduced by three-color process from living cultures. The cultures were in all cases, unless otherwise specified, forty days old when photographed, and were grown at laboratory room temperature ranging from 20° to 25° C.

Cultures of Plates I to IV were, with a few specified exceptions, grown on hard potato agar with 10 per cent glucose, and were kept in a strong diffuse daylight and in air nearly saturated with moisture.

All cultures of Plates V to VII were on sterilized potato tuber plugs in test tubes which were kept at the above temperature but in very weak diffuse light.

PLATE I. FUSARIA OF POTATOES

Fig. 1. Fusarium Solani, from above
Fig. 2. F. striatum, from above
Figs. 3 and 4. F. Martii var. minus: 3, on acidified medium from below; 4, on hard oat agar from above
Figs. 5 and 6. F. coeruleum, from above and below
Figs. 7 and 8. F. oxysporum var. resupinatum, from above and below
Figs. 9 and 10. F. lutulatum var. zonatum, from above and below
Figs. 11 and 12. F. sclerotioides, in dark, from above and below

PLATE I—FUSARIA OF POTATOES

PLATE II – FUSARIA OF POTATOES

PLATE III. FUSARIA OF POTATOES

Fig. 1. Fusarium sporotrichioides, from above; in dark
Fig. 2. F. bullatum var. roseum, from above
Figs. 3 and 4. F. arthrosporioides, from above and below; in dark
Figs. 5 and 6. F. sanguineum var. pallidium, from above and below
Figs. 7 and 8. F. sanguineum, from above and below; in dark
Figs. 9 and 10. F. ferruginosum, from above and below
Figs. 11 and 12. F. clavatum, from above and below

PLATE III—FUSARIA OF POTATOES

PLATE IV. FUSARIA OF POTATOES

Figs. 1 and 2. Fusarium culmorum var. leteius, from above and below.
Fig. 3. F. subpallidum var. roseum, from above; on slightly acidified medium
Fig. 4. F. discolor, from below
Figs. 5 and 6. F. discolor var. triseptatum: 5, from above, in dark on neutral medium; 6, from above, in light on slightly acidified medium
Fig. 7. F. caudatum var. Solani, from above, neutral medium
Fig. 8. F. trichothecioides, from above
Fig. 9. F. culmorum from above, on hard oat agar
Fig. 10. F. culmorum var. leteius, from above, on hard oat agar
Fig. 11. F. discolor var. sulphureum, from above
Fig. 12. F. lucidum, from above, slightly acidified medium, fifteen days old

PLATE IV—FUSARIA OF POTATOES

PLATE V. FUSARIA OF POTATOES

Fig. 1. Fusarium sclerotioides
Fig. 2. F. redolens var. Solani
Fig. 3. F. lutulatum
Fig. 4. F. lutulatum var. zonatum
Fig. 5. F. oxysporum var. resupinatum
Fig. 6. F. oxysporum
Fig. 7. F. oxysporum var. asclerotium
Fig. 8. F. culmorum
Fig. 9. F. culmorum var. leteius
Fig. 10. F. discolor var. triseptatum
Fig. 11. F. discolor
Fig. 12. F. subpallidum

PLATE V—FUSARIA OF POTATOES

PLATE VI. FUSARIA OF POTATOES

Fig. 1. Fusarium sanguineum
Fig. 2. F. ferruginosum
Fig. 3. F. caudatum var. Solani
Fig. 4. F. coeruleum
Fig. 5. F. Martii var. viride
Fig. 6. F. Martii var. minus
Fig. 7. F. Solani
Fig. 8. F. radicicola
Fig. 9. F. anguioides var. caudatum
Fig. 10. F. arcuosporum
Fig. 11. F. anguioides
Fig. 12. F. lucidum

PLATE VI—FUSARIA OF POTATOES

PLATE VII. FUSARIA OF POTATOES

Fig. 1. Fusarium truncatum
Fig. 2. F. clavatum
Fig. 3. F. subulatum var. brevius
Fig. 4. F. subulatum
Fig. 5. F. metacroum
Fig. 6. F. effusum
Fig. 7. F. sanguineum var. pallidium
Fig. 8. F. falcatum var. fuscum
Fig. 9. F. arthrosporioides var. asporotrichius
Fig. 10. F. biforme
Fig. 11. F. arthrosporioides
Fig. 12. F. diversisporum, pseudopionnotal stage

PLATE VII—FUSARIA OF POTATOES